THE WILEY FARM SERIES

EDITED BY

A. K. GETMAN

CHIEF, AGRICULTURAL EDUCATION BUREAU, NEW YORK STATE DEPARTMENT OF EDUCATION

AND

C. E. LADD

DEAN, NEW YORK STATE COLLEGE OF AGRICULTURE

CORN AND CORN GROWING

THE WILEY FARM SERIES

EDITED BY

A. K. GETMAN

Chief, Agricultural Education Bureau, New York State Department of Education

AND

C. E. LADD

Dean, New York State College of Agriculture

Rural Water Supply and Sanitation. By FORREST B. WRIGHT. Cloth, 5⅜ by 8, 288 pages, 184 illustrations.

A Workbook for Students in Field Crops. By WILLIAM ANDERSON BROYLES. Paper, 8½ by 11, 123 pages, illustrated.

Orchard and Small Fruit Culture. By E. C. AUCHTER amd H. B. KNAPP. Third edition. Cloth, 6 by 9, 627 pages, 278 illustrations.

Crop Management and Soil Conservation. By JOSEPH F. COX and LYMAN E. JACKSON. Cloth, 5½ by 8, 610 pages, 199 figures.

Electricity in the Home and on the Farm. By FORREST B. WRIGHT. Cloth, 5⅜ by 8, 320 pages, 66 figures.

The Young Man in Farming. By A. K. GETMAN and P. W. CHAPMAN. Cloth, 5½ by 8, 216 pages, 17 figures.

Producing Farm Livestock. By J. L. EDMONDS, W. G. KAMMLADE, W. B. NEVENS, R. R. SNAPP, and W. E. CARROLL. Cloth, 5½ by 8, 439 pages, 111 figures.

Workbook in Producing Farm Livestock. By J. L. EDMONDS, W. G. KAMMLADE, W. B. NEVENS, R. R. SNAPP, and W. E. CARROLL. Paper, 8½ by11, 100 pages.

Farm Tractors. By A. A. STONE. Cloth, 5½ by 8, 492 pages, 357 figures.

Growing Tree and Small Fruits. By H. B. KNAPP and E. C. AUCHTER. Cloth, 5½ by 8, 510 pages, 224 figures.

Future Farmers in Action. By ARTHUR KENDALL GETMAN. Cloth, 5½ by 8, 115 pages.

Corn and Corn Growing. By H. A. WALLACE and E. N. BRESSMAN. Fourth Edition, completely revised. Cloth, 5½ by 8, 436 pages, 117 figures.

Alfalfa. By J. F. COX and C. R. MEGEE. Cloth, 5½ by 8, 101 pages, 43 figures.

Farm Machinery. By A. A. STONE. Second Edition. Cloth, 5½ by 8, 466 pages, 285 figures.

Dairy Cattle. By W. W. YAPP and W. B. NEVENS. Second Edition. Cloth, 5½ by 8, 390 pages, 117 figures.

Practical Poultry Management. By JAMES E. RICE and H. E. BOTSFORD. Third Edition. Cloth, 5½ by 8, 592 pages, 348 figures.

Farm Engineering. By B. B. ROBB and F. G. BEHRENDS. FARM MECHANICS —Vol. I. Cloth, 5½ by 8, 453 pages, 470 figures.

Crop Production and Management. By JOSEPH F. COX. Second Edition Revised. Cloth, 5½ by 8, 469 pages, 188 figures.

Seed Production and Marketing. By JOSEPH F. COX and GEORGE E. STARR. Cloth, 5½ by 8, 450 pages, 193 figures.

Farm Soils: Their Management and Fertilization. By E. L. WORTHEN. Second Edition. Cloth, 5½ by 8, 468 pages, 220 figures.

CORN AND CORN GROWING

BY

HENRY A. WALLACE

Secretary of Agriculture

AND

EARL N. BRESSMAN

Scientific Adviser, U. S. Dept. of Agriculture

FOURTH EDITION

COMPLETELY REVISED

NEW YORK

JOHN WILEY & SONS, INC.

LONDON: CHAPMAN & HALL, LIMITED

1st Edition = 1923
2nd " = 1925
3rd " = 1928
4th " = 1937

PRINTED IN U. S. A.

PRESS OF
BRAUNWORTH & CO., INC.
BUILDERS OF BOOKS
BRIDGEPORT, CONN.

PREFACE TO THE FOURTH EDITION

THE first three editions of "Corn and Corn Growing" have been exhausted. For the fourth time, in response to a continued demand, the authors have completely revised the book. Many corrections and adjustments have been made throughout, but the greatest emphasis has been placed on the revisions that deal with the economics and with the genetics of corn. In the Appendix the figures have been brought up to date and new material has been added. It is hoped that these changes and additions will make the new edition even more useful than the older ones. The authors are greatly indebted to Louis Bean, Floyd J. Hosking, Preston Richards, Martin Reese Cooper, and Charles F. Sarle, as well as other members of the U. S. Department of Agriculture, for many valuable suggestions and contributions.

H. A. WALLACE
E. N. BRESSMAN

CONTENTS

CORN AND CORN GROWING

CHAPTER I

PICKING AND STORING SEED CORN

PICKING SEED CORN

THE safest time to pick seed corn is in late September or early October. Early picking is especially worth while in such years as 1915, 1917 and 1924, when the months of June, July and August are unusually cool and rainy. Corn which contains more than 30 per cent moisture is quite easily damaged by ordinary freezing weather, such as oftentimes occurs in late October and early November.

The method to use.—The amount of seed to be picked, cost of equipment and climatic conditions will determine the method of picking seed corn that is best for any particular situation.

Most farmers who pick their seed corn in early October go through the field with a sack over their shoulder. This is a very good but somewhat tiresome method. A more convenient method employed by some farmers is to drive through with a regular wagon fitted up with bang-boards as for ordinary husking. Six or seven rows are husked instead of two, but only the best 20 to 30 per cent of the ears are thrown into the wagon. When the end of the field is reached, the team can be turned to come back on the same down row, with the result that seed is thrown into the wagon from a total width of twelve to fourteen rows for each down row. A single day in the field with this

kind of an outfit will give the average farmer all the seed he needs for the following year.

The kind of ears to pick.—The man who picks seed corn in the field does not have any time to examine in great detail the characteristics of each ear. He can, however, pick ears that are carried on stiff stalks about four feet from the ground, ears which are medium large, well matured, and solid. No ear should be saved which is moldy or which comes from a stalk infested with smut, rot, or any other kind of disease. In Illinois, Iowa and Nebraska, it seems to be decidedly worth while to pick for ears with a rather smooth dent, ears with kernels which are smooth, shiny and horny. At the Nebraska station, after six years of experimenting, it was found that the ears with rather shallow, smooth and flinty grains yielded from four to five bushels per acre more than ears with deep, rough and somewhat starchy grains.

FIG. 1.—Picking seed corn. He sees a solid ear, well matured on a healthy stalk.

Experiments at many different stations have proved that it does not pay to pick the seed ears for any pronounced type. At the Ohio station, for instance, after ten years' work it was found that the seed ears 6 or 7 inches long yielded within a bushel or two per acre as much as the seed ears 9 or 10 inches long. Seed ears which were tapering yielded a bushel or two

more per acre than those which were cylindrical. Ears with an inch of bare tip showing yielded almost exactly the same as those with the tips completely filled. The smooth ears yielded about two bushels per acre more than the rough ears, the difference in favor of the smooth ears not being nearly so pronounced as in Nebraska.

. Iowa experiments indicate that ears with broad, thick kernels yield on the average four or five bushels more per acre than ears with narrow, thin kernels of a shoe-peg type. Apparently, about all that can be done so far as type of ear is concerned, when picking seed corn in the fall, is to select solid, well-matured ears with rather broad, thick kernels. During the winter it may be possible to go over the ears more carefully after they are hung up, but in the field it is impracticable to spend more than a second or so on any individual ear.

The importance of early picking.—Corn, when it first becomes well dented and hard glazed, contains about 40 per cent moisture. In the ordinary year, in the central part of the corn belt, the best matured ears reach this stage about the middle of September. In cold, backward seasons like 1915, 1917 and 1924, however, only a few of the ears will be well dented, hard and down to 40 per cent moisture by October 1. A well-dented ear of this sort will stand the ordinary light frost without damage. If, however, the temperature goes below 20° for more than eight or ten hours, very serious damage is likely to be done, even to the more mature corn.

Table I, taken from Bulletin 188 of the Nebraska experiment station, illustrates why it is so important to protect seed corn from freezing until its moisture has been reduced to less than 15 per cent.

In many seasons, when the weather is rather hot and dry during August and September, the best matured ears will contain less than 20 per cent moisture on October 1, and there is not much chance of serious damage to the corn for seed even though it is left out until Christmas time. In most years, however, even the best matured seed ears contain around 20 per

cent moisture in the middle of October and are therefore likely to be damaged if the temperature goes below 15°.

TABLE I

RELATIVE GERMINATION OF CORN OF VARYING MOISTURE CONTENT PER CENT

Moisture content of grain (per cent)	10 to 15	15 to 20	20 to 25	25 to 30	30 to 35	35 to 40	40 to 45	45 to 50	50 to 55	55 to 60	60 to 65
Temperature ranges in degrees F.											
32 to 28........	100	100	100	85	75	71	69	*	33	31	0
24 to 20........	100	100	96	77	67	13	12	12	6	0	0
16 to 12........	100	100	88	34	12	0	0	0	0	0	0
8 to 4........	100	98	47	7	0	0	0	*	0	*	*
0 to −5......	97	63	0	0	0	0	0	0	0	0	0

* No tests run with corn of this moisture content at this temperature.

MISCELLANEOUS METHODS USED

It is still possible oftentimes to get good home-grown seed corn even though it is not picked out of the field in early October. In the average year it is possible to get good seed corn at husking time, and many farmers therefore put a box on the side of their wagon in which they place the best looking seed ears. Other farmers pick their seed ears out of the husked corn as it is being shoveled or elevated into the crib. Others wait until spring and pick their seed corn out of the crib. About half the time, according to experiments conducted at the Ohio station, crib corn germinates and yields very satisfactorily, but the other half of the time the yield is likely to be very seriously reduced because of low germination. Crib corn, if it is given a very careful ear by ear test, is quite satisfactory, but the labor of giving an ear by ear test is greater than picking the seed corn

in early October and storing it where it will not be damaged by freezing weather. Moreover, the yielding power of ear-tested crib corn is not quite so good on the average as corn which is picked early and properly hung.

STORING SEED CORN

Seed corn when brought in from the field in early October ordinarily contains from 30 to 40 per cent moisture, and the

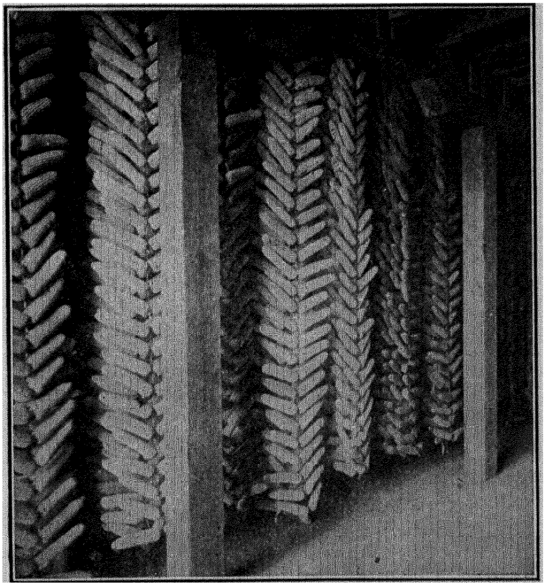


FIG. 2.—A full seed corn house.

object in storing is to reduce this moisture content as rapidly as possible so that there will be no likelihood of freezing injury. The ears should be properly stored in a dry, well-ventilated place where there is little danger of freezing until the kernels have been reduced to less than 15 per cent moisture.

The place to store seed corn.—There are many places on the farm where seed corn is stored. Some of these places are

satisfactory and others are objectionable. A heated room in the house appears to be best if a special seed corn building is not available. Growers who are making a business of producing seed corn should have a well-built house just for seed corn. This house should not only have all of the requirements of seed protection such as ventilation, dryness and heat, but also should be convenient for storing, testing, shelling, grading and shipping the product.

TABLE II

YIELDING POWER OF SEED CORN STORED IN DIFFERENT WAYS.
(OHIO STATION)
Germination, Per Cent

Methods of Storage	1913	1914	1915	1916	1917	Five-Year Aver.
Lot 1—In rack over crib.........	97.50	94.33	97.83	92.33	99.50	96.30
Lot 2—In pile on floor over crib...	92.00	89.00	97.00	92.17	98.33	93.70
Lot 3—In crib..................	88.17	92.67	95.33	72.33	98.50	89.40
Lot 4—In rack in warm room.....	96.67	95.50	98.83	95.83	99.17	97.20
Lot 5—In furnace room, hung up..	98.67	94.33	97.33	98.33	99.00	97.53
Lot 6—In bin of oats............	87.17	94.83	98.83	85.00	98.33	92.83

Yield of Corn Per Acre, Bushels

Methods of Storage	1913	1914	1915	1916	1917	Five-Year Aver.
Lot 1—In rack over crib.........	81.54	59.21	55.97	60.10	106.06	72.58
Lot 2—In pile on floor over crib...	79.07	58.86	54.85	61.12	106.53	72.09
Lot 3—In crib..................	74.25	62.86	59.86	50.00	108.14	71.02
Lot 4—In rack in warm room.....	78.64	65.29	59.64	60.02	103.89	73.50
Lot 5—In furnace room, hung up..	77.89	68.07	62.59	59.87	106.89	75.06
Lot 6—In bin of oats............	72.32	66.57	55.88	53.75	107.50	71.20

At the Ohio station, as an average of five years, it was found that corn hung up in the furnace room yielded best, whereas crib corn and corn stored in the oat bin yielded poorest. In

this Ohio experiment the corn was all picked in the field at the same time, and so it is safe to say that the difference in germinating power and yield are due to the method of storage and not to any difference in time of picking. It will be noted that in one year the crib corn yielded more than the corn stored in any of the other ways, but that as an average of the five years the corn hung up in the furnace room yielded an average of several bushels more per acre.

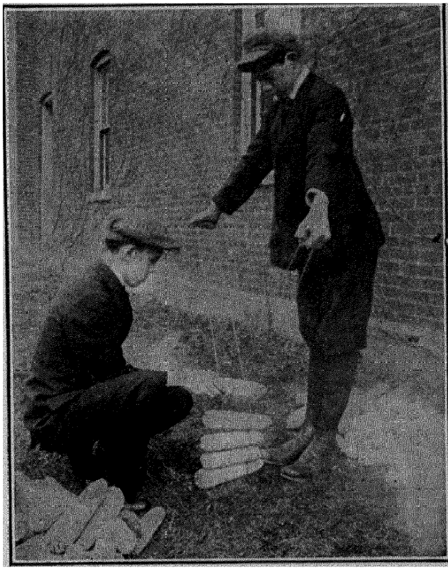


FIG. 3.—The twine hanger.

If seed corn kept in a heated room will yield several bushels per acre better than corn hung over a crib, it may be worth while for farmers to fix up a place in their furnace room or attic or in a spare room for seed corn. Of course, a damp cellar or a closed attic where there is poor ventilation of air should be avoided. The two objects are to dry out the corn and to protect it from freezing until it is thoroughly dry.

In 1918, following the cold, backward season of 1917, germination tests were run by the Ohio station in the same way as during the five-year period, 1913–17. The crib corn (Lots 1, 2 and 3) germinated less than 9 per cent. The corn in the bin of oats germinated 86 per cent, and the corn in the warm room and furnace room germinated better than 93 per cent. No yield test was run in 1918. Apparently, heat dried corn has only a slight advantage in the ordinary year, but following a

backward season like 1917 the corn which is not artificially dried is likely to be a complete failure.

Method of Hanging Seed Corn.—Many methods have been devised for hanging seed corn so that there will be a free circulation of air around the ears to carry off the moisture as rapidly as possible. A number of seed corn racks are on the market which are very convenient. However, one of the cheapest, most convenient and most satisfactory hangers for storing seed corn can be made out of electric-welded hog-tight fencing. The electric-welded fence wire has a 2 x 4 rectangular mesh and the hangers are cut from it the long way. Every other wire is cut in such a way that 4-inch prongs are left for a pair of ears each 4 inches. The wire may be cut with a cold chisel and a hammer, using a piece of iron on which to rest the wire as shown in picture on next page, or a pair of sharp lineman's cutting pliers may be used.

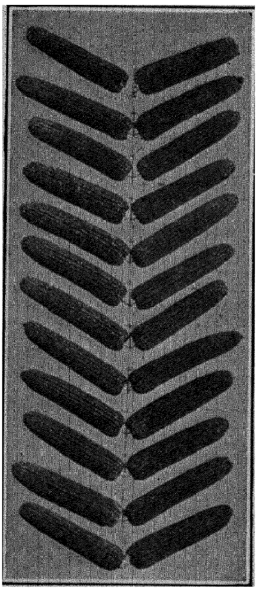


Fig. 4.—Hanging seed corn on electric welded fence wire.

Ordinarily it is best to cut these hangers so that each hanger will accommodate from ten to fifteen pairs of ears. By using a pair of pliers, the end of the main rib of a hanger can be bent so that several of them may be attached one to the other.

Farmers who have used this type of seed corn hanger with several hundred bushels have found it thoroughly satisfactory and cheaper than any other hanger they can buy. The cost of the labor and material for preparing the hangers for a thousand ears need not exceed two dollars. After the corn is taken from the hangers in the spring, they can be wired together conveniently and stored away in a small space.

Some people make hangers by driving nails into boards, poles or posts. Others make lath racks by tacking laths 4 inches apart on each side of 4-inch uprights. There are scores of such devices, all of which are good.

Drying with artificial heat.—Seedsmen specializing in seed corn have worked out several different devices for forcing heated air through the corn in a bin. The corn is picked in early October and thrown into the bin, and the heated air is

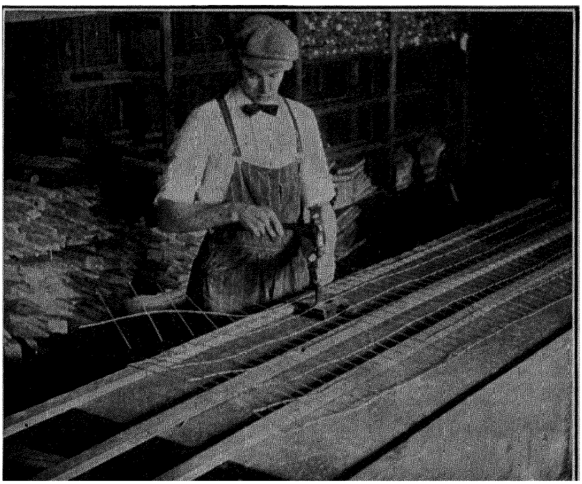


FIG. 5.—Making seed corn hangers out of electric welded fence. Note the alternate wire method of cutting.

immediately forced through it, the object being to reduce the moisture content of the corn from above 30 per cent to less than 10 per cent within three or four days. The standard method is to have a bin about 8 feet each way with tight sides and a slatted bottom with an air chute below the slatted bottom. A furnace and blower or fan are used to force the hot air through the corn. It seems to be essential, if the germinating power of the corn is not to be damaged, that the temperature of the air should not be above 120°. On the other hand, it should not be

below 100° if the moisture is to be carried off most economically. It seems that a plan of this sort is not practicable except where more than 500 bushels of seed corn is being handled each year.

Fuel and power to dry a bushel of corn in early October costs about 15 cents. Ordinarily the drying is completed in three or four days when the air is forced through the corn at a temperature of 110°. Germination tests have proved that corn dried in this way contains less mold than the same kind of corn dried on hangers in the ordinary farm manner. One of the authors of this book has used this method for several years with excellent results.

SELECTED LIST OF REFERENCES

WILLIAMS, C. G., and WELTON, F. A. Corn Experiments. Ohio Bul. 282. 1915.

KIESSELBACH, T. A., and RATCLIFF, J. A. Freezing Injury of Seed Corn. Nebr. Res. Bul. 16. 1920.

KIESSELBACH, T. A. Corn Investigations. Nebr. Res. Bul. 20. 1922.

KIESSELBACH, T. A. Productive Seed Corn. Nebr. Bul. 188. 1923.

DUNGAN, G. H. Some Factors Affecting the Water Absorption and Germination of Seed Corn. Jour. Amer. Soc. Agron. Vol. 16. No. 8 Pp. 473-81. 1924.

CHAPTER II

HARVESTING CORN

THE six general methods of harvesting are:

1. Husking the ears by hand from standing stalks.
2. Snapping the ears by hand from standing stalks.
3. Husking the ears by machine from standing stalks.
4. Cutting the stalks for silage.
5. Cutting the stalks for fodder.
6. Harvesting with livestock.

The fourth and fifth of the methods listed above are discussed in a later chapter.

DETERMINING THE METHOD OF HARVEST

The use that the grower wishes to make of the crop is the most important factor in determining the method of harvest. Other factors such as climatic conditions, labor available and storage conditions are often important considerations.

Husking by hand.—Most of the crop in the Corn Belt is husked by hand from the standing stalks after heavy frost. At this time the ears are dry enough to crib and they break from the stalks more easily. Before corn is picked, the husks should be dry and the kernels hard. Ordinarily, harvest begins the latter part of October and is completed at Thanksgiving time, but fields occasionally stand throughout the entire winter.

The two methods of husking by hand from standing stalks are peg husking and hook husking. The pioneers used a husking peg or pin, somewhat similar to that illustrated here, but usually made it either out of hickory wood or bone. Peg husk-

ing was universal until the late nineties, when hook husking began slowly to displace it, especially among the younger generation. To-day most of the corn of Iowa, Illinois and Nebraska is husked with a hook. The first hook was invented by W. F. Lillie of Gage county, Nebraska, in 1892, in order to make it possible for an uncle who had lost a thumb to husk corn. An altogether different motion was required with the hook than with the peg, and the new invention did not begin to make much progress until 1896.

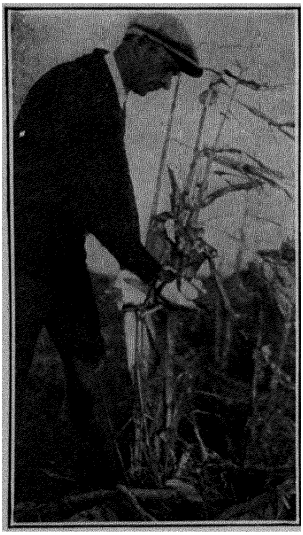


FIG. 6.—Corn husking champion Fred Stanek at work.

To-day the average peg husker husks about 70 bushels in a ten-hour day and the average hook husker about 85 bushels. Practically all of the really fast corn husking has been done with the hook. Young men who have developed special skill in husking with the hook have, with all conditions favorable, husked 250 bushels in ten hours' field husking time. Under contest conditions, it has been proved that with all conditions favorable it is possible to husk 35 bushels in an hour. A champion husker husking this fast will leave about one ear in fifty behind and will leave about 7 or 8 ounces of husks on 100 pounds of ears.

The condition of the corn has a lot to do with the speed of husking. When the corn weighs 70 pounds per 100 ears, the records will be about 30 per cent faster than when it weighs 50 pounds per 100 ears. And, of course, much better records can be made if the corn is standing up well with the husks hanging loose. The smaller-eared, more thickly planted, heavier-husked corn of northern Iowa is much harder to husk fast than

the typical Reid corn of southern Iowa. Reid corn has a smaller shank and thinner husk than such varieties as Leaming and Silver King.

In the typical hook husking method, in the case of the ordinary ear hanging point downward, the motions are: First, the left hand grasps the ear about the middle with the thumb down or toward the point of the ear, and the tip of the ear is elevated a few inches. Almost simultaneously the right hand with the hook on it is swept across the husks on the under side of the ear, cutting them and making it possible for the fingers of the right hand to grasp the ear free of husks. The

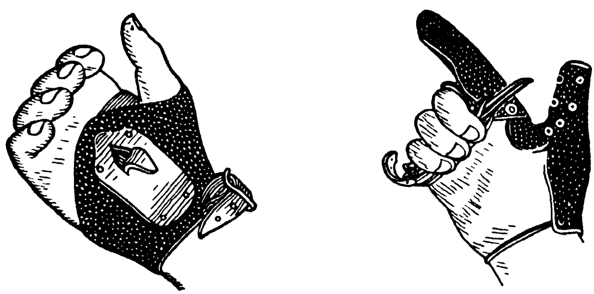


FIG. 7.—*Left,* modern husking hook. *Right,* old-fashioned husking peg.

left hand on the upper side of the ear holds the husks back on that side, and the right hand jerks the ear loose and swings it into the wagon with a single motion. It all sounds quite complicated, but the various motions are done so nearly at the same time that good huskers can husk forty ears a minute and keep it up. It is possible for short periods of time to husk more than fifty ears a minute.

In the case of peg husking, there are three distinct motions which do not blend into each other quite so smoothly as in hook husking. Peg husking is cleaner than hook husking, however, and the average peg husker will leave only about 3 ounces of husks on 100 pounds of ears, compared with about 7 or 8 ounces for a hook husker.

With both hook husking and peg husking, the typical method is for one man with a team and wagon to pick two rows across the field. The wagon is equipped on the side opposite the picker with a "bang board" about 3 feet high, against which the picker throws the husked ears.

In the matter of husking corn from the standing stalks, the farmers of Iowa, Illinois and Nebraska are the most efficient in the world. In most other sections of the world, the workers take nearly twice as long to husk 100 bushels of corn as do the farmers of the Corn Belt. The farmers of to-day are also twice as fast as their forefathers who followed the plan of having several members of the family husk into the wagon, throwing from both sides, and with a child picking up the down row.

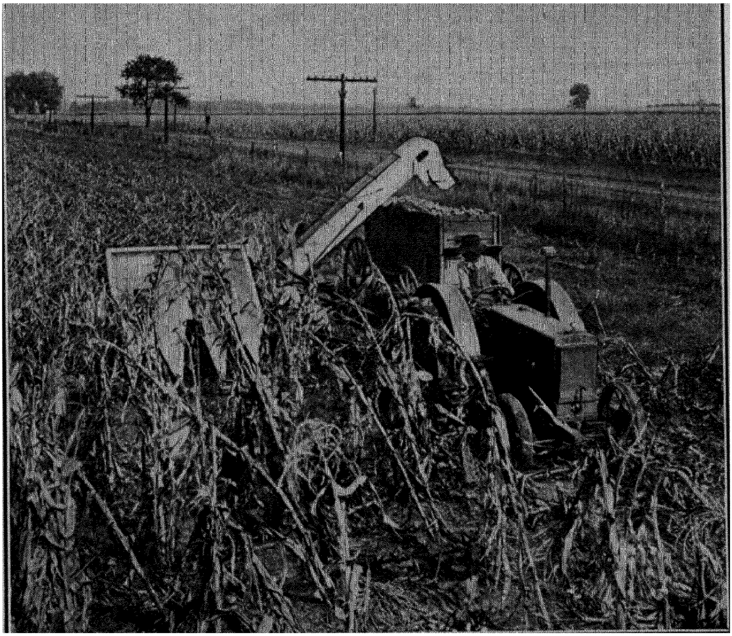
Snapping corn.—Snapping is the breaking of the ear from the stalk, without removing the husk. This practice is common in the South, where corn dries out well and there is danger of injury in the crib from moths or weevils. In the Corn Belt, corn fed directly from the field early in the fall is snapped in order to save the labor of husking. Sweet corn is usually snapped and hauled directly to the cannery. Ordinarily, corn for cribbing is not snapped because:

1. The husks interfere with the drying of the corn in the crib.
2. The husks take up storage room.
3. The husks interfere with corn shelling, except in the case of big power shellers.

Husking by machine.—Corn-husking machines are being used more extensively each year in those sections where the fields are large and level and where ordinarily it is difficult to get labor for husking in November. The machine has been perfected to a point where it is remarkably successful in picking corn from down stalks. When weather conditions are favorable the husking machine leaves less corn behind in the field and less husks on the corn in the wagon than is the case with the average hand picker.

The great trouble with the machine is that within a few weeks after freezing weather, the shanks holding the ears to the

stalk become very brittle, and many ears fall to the ground very easily. It is universal experience that the mechanical picker gives best results in rather damp weather, provided the ground is dry under foot. Another objection to the mechanical picker is that it tears up the stalks so that there is little feed left on them for the stock.



(*Courtesy U. S. D. A.*)

FIG. 8.—Mechanical corn pickers give satisfaction under some conditions.

In order for the picker to become a decided success in the larger corn-growing sections of the Corn Belt, it is essential that tough shanked varieties of corn be developed. It will also help if the stalks are stiff and upright. Reid corn has a small, weak shank, which is ideal for hand husking, but poor for machine husking. There is a real opportunity for a corn breeder to develop a high-yielding strain of corn especially adapted to machine husking. Incidentally, it would seem that

a two-eared type would be worth while for machine husking. Also the ears should be rather hard shelling, which probably means that the kernels would be rather shallow and smooth. It may be well to have the ears carried lower on the stalk with machine husking than with hand husking.

The one-row picking machine husks about three-quarters of an acre an hour, the yield of the corn per acre having practically no influence on the speed. Two-row machines pick as much as 3 acres per hour. With a tractor equipped with a power take-off and a wagon hitch, it is possible for one man to drive the tractor which is pulling both the picking machine and the wagon. Another man and team are kept busy hauling and unloading. With a tractor it is possible to husk an acre an hour on the assumption that the tractor is traveling 2.5 miles per hour. With five horses on a machine, the typical speed after taking time out for adjustments is probably just a little less than two miles an hour, or about two-thirds of an acre an hour. Farmers with 100 acres of corn in fairly level fields have found it possible, figuring the cost of husking at 5 cents a bushel, to save enough to pay the necessary $400 for a corn-husking machine in three or four years. Other farmers who have no particular love for machinery have discarded their husking machines after one year of use. It is probable that those farmers with more than 70 acres of level corn to husk each year will become more and more interested in corn-husking machines, especially if varieties of corn are developed that are well adapted to machine husking.

In 1928 the two-row machine was introduced. A comparison of the one-row machine, the two-row machine, and hand husking in Indiana is of interest.

The Purdue University Agricultural Experiment Station reports: "Farms growing large acreages of corn have been, in most cases, the ones which have used mechanical corn pickers. The one-row pickers in this study picked an average of 88 acres of corn on the home farms while the two-row pickers picked 124 acres at home. It was on these large acreages that the labor problem involved in corn husking was

most acute and it was also on these farms that the overhead costs involved in using a picker could be spread over a large acreage with consequent low picking costs.

"The three years of this study 1929, 1930 and 1931 were marked by a rapid decline in the costs of farm labor with consequent lowered costs for both hand and machine husking. Average prices (including board) paid per bushel for hand husking declined from 6.9 cents in 1929 to 3.0 cents in 1931. Costs of the man labor used in mechanical picking also declined, but since man labor made up but 25 per cent of the cost of picking with one-row pickers and 22 per cent of the costs with two-row pickers the costs of hand husking declined much more than did the costs of machine husking.

"Machine husking, particularly with two-row pickers, was more economical on most of the farms in this study during the 1929 and 1930 seasons than was hand husking. During the 1931 season hand husking costs were so low that machine husking in most cases was not economical."

Even now, corn-picking machines seem to have been sufficiently perfected to be a decided success on the larger farms where all conditions are favorable. All conditions are not likely to be favorable, however, for more than one-fourth of the time with the types of corn which are now most generally grown in the Corn Belt. There is a real opportunity for someone to develop types of corn genuinely adapted to the corn-husking machine.

In standing corn, during October, the machine seems to give better results than the ordinary husker, picking many nubbins which most huskers pass up and leaving less in the way of silks and ribbons on the corn in the wagon. But as the season wears on and the stalks become brittle and some of the ears drop off, the machine seems to labor under a serious handicap. Ideal picking conditions are:

1. Upright hard-shelling corn.
2. Stalks and husks not too brittle.
3. Dry ground in the field.
4. Cloudy or damp weather.
5. Upright short stalks with ears carried low.

Heretofore, in the Corn Belt, corn breeders have selected the single-eared types of corn because of the greater labor of husking two-eared stalks. With the corn-husking machine, however, there may be a positive advantage in two-eared sorts.

With hand huskers, it is inadvisable for corn to carry the ears much lower than waist high, but with the machine it is permissible for the ears to be as low as 2 feet from the ground. For the picking machine, it seems that a rather smooth-kerneled, shallow-grained sort which clings tightly to the cob would be better than a deep-grained, rough, easy-shelling kind.

Reid Yellow Dent and varieties of corn similarly bred are responsible for a large part of the difficulty with corn-picking machines. Reid Yellow Dent is an ideal variety for hand huskers as it carries a large ear on a small shank and breaks off easily. It is just about the worst possible variety for machine husking.

Even under ideal conditions, when the machine picks cleanly, there are some objections to the mechanical picker:

1. Power must be supplied by several horses or a tractor.
2. Field losses are greater in unfavorable weather.
3. It tears down the stalks and leaves them in poor condition for pasturing.
4. It is expensive.
5. It is dangerous to hands if a man is careless.

Time required for husking.—According to the 1922 Yearbook of the United States Department of Agriculture, about the following number of bushels may be husked in a ten-hour day:

	Bushels
From shock, by hand, one man	45.0
From standing stalks, by hand, one man, two horses	85.0

A leading manufacturer of corn-husking machines claims that in fifty-bushel corn, two men, seven horses, a one-row machine and two wagons will husk at least 300 bushels, and probably 375 bushels in a ten-hour day.

Elevating the corn.—The larger Corn Belt farms usually have a portable elevator for delivering the husked corn from the wagon to the crib. These elevators save a large amount of hand labor required when the corn is scooped by shovel

from the wagon into the crib. The corn is dumped and elevated by power furnished by a team or gasoline engine. A crib may be entirely filled with no hand labor. For shoveling, the wagon is equipped with a special end-gate, which provides room for the shoveler to stand.

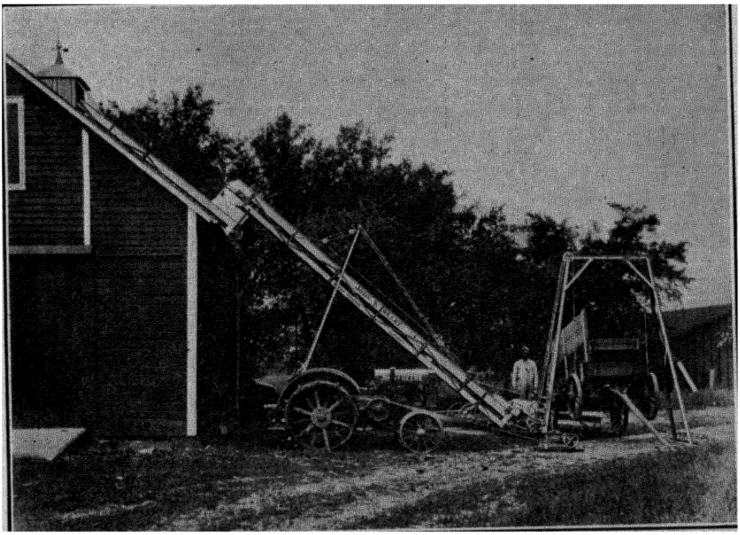


FIG. 9.—Cribbing corn with portable elevator.

STORING THE CORN

Corn Cribs.—A good corn crib should provide for the following:

1. Ventilation.
2. Protection from rodents.
3. Exclusion of moisture.
4. Accessibility to the feed lot.
5. Permanency.

Most of the cribs are of wood with slatted siding. These cribs are of varying lengths, but are quite uniformly 8 feet wide, so that good ventilation is obtained. In years of large

corn crops, much corn is placed in temporary wire or stave fence cribs. For permanency, farmers have been building cribs of special hollow tile that has a channel extending downward toward the outside of the crib. These circular cribs with central ventilators and cement floors have proved very satisfactory.

Steel corn cribs have also been coming into use in recent years.

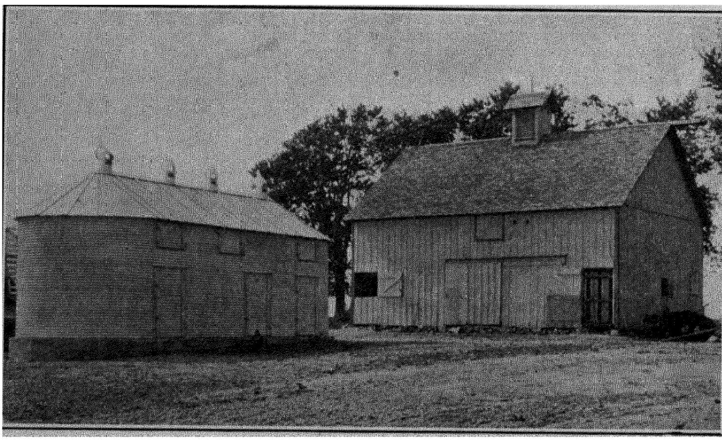


FIG. 10.—A steel corn crib on a concrete base makes an ideal place to store corn.

Moisture in corn.—It is not safe to crib, in an ordinary crib, ear corn that has more than 27 per cent moisture. In an average year at husking time, corn will contain from 20 to 30 per cent moisture. There is a rapid decrease during October and November in the amount of moisture in crib corn, and again in the spring months.

From November until the following October, corn will lose from 8 to 20 per cent in weight, depending upon conditions. As a rule, there will be about 17 per cent shrinkage in ordinary corn the first year. The second year there is a small amount

of shrinkage in crib corn, usually less than 1 per cent. (See Chapter XXII.)

Measuring corn.—To find the number of bushels of shelled corn in a bin, multiply the length by the width by the depth (all in feet), and divide by 1.25. To find the number of bushels of ear corn, divide by 2.5. If the corn is in the husk, divide by 3.5. For a round crib, multiply the distance around the crib by the diameter by the depth of the corn (all in feet) and divide by 10 to get the number of bushels of ear corn; if

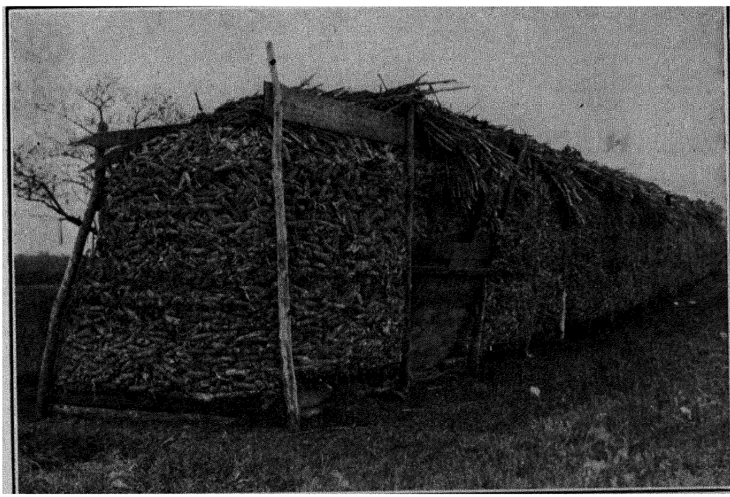


FIG. 11.—A cheap, temporary corn crib which permits loss by weather and rats.

the corn is in the husk, divide by 14.5. A common wagon box is 10 feet long and 3 feet wide. It will hold two bushels of shelled corn or one bushel of ear corn for every inch of depth. There are 2150.42 cubic inches in a bushel of shelled corn, and 4300 cubic inches in a bushel of ear corn (allowing 70 pounds of ear corn to the bushel). If the corn is unusually deep

grained, smooth dented, and well matured, 3800 cubic inches of ear corn may shell out a bushel.

Shelling Corn

Ear corn containing not more than 25 per cent moisture shells readily, and in the frozen state corn with more moisture

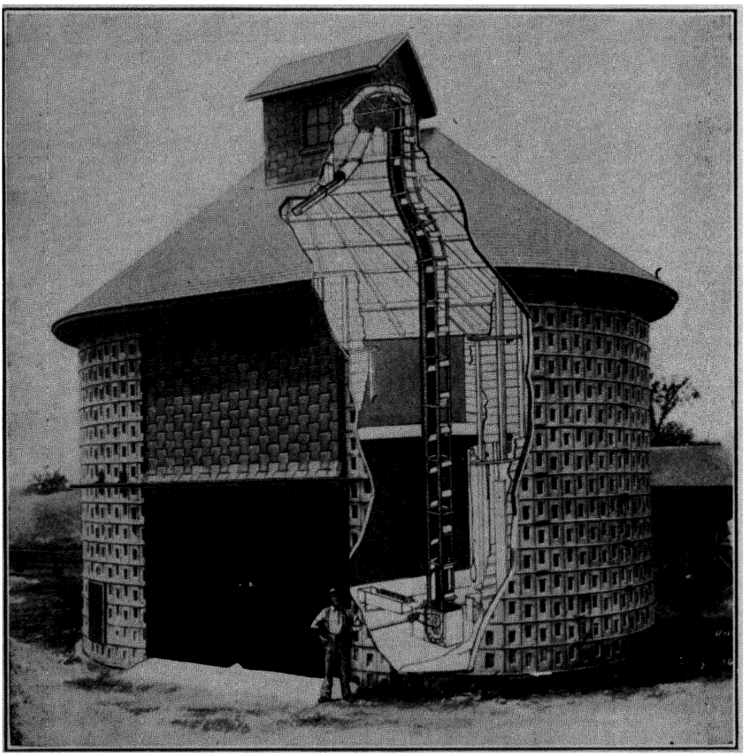


Fig. 12.—Illustrating inside elevator in a cement stave corn crib.

shells fairly well. However, it is not safe to bin shelled corn containing more than 17 per cent moisture. If shelled corn is to be stored beyond April 15, it should not contain more than 15 per cent moisture, or it is likely to heat seriously dur-

ing the first spell of warm weather. Grade 3 corn, which contains not more than 17.5 per cent moisture, may be safely shipped in warm weather.

The two types of corn shellers are the spring sheller and the cylinder sheller. Most of the small power shellers and hand shellers are of the spring type. These shellers have an adjustable rag iron that holds the ears against a deep-grooved wheel

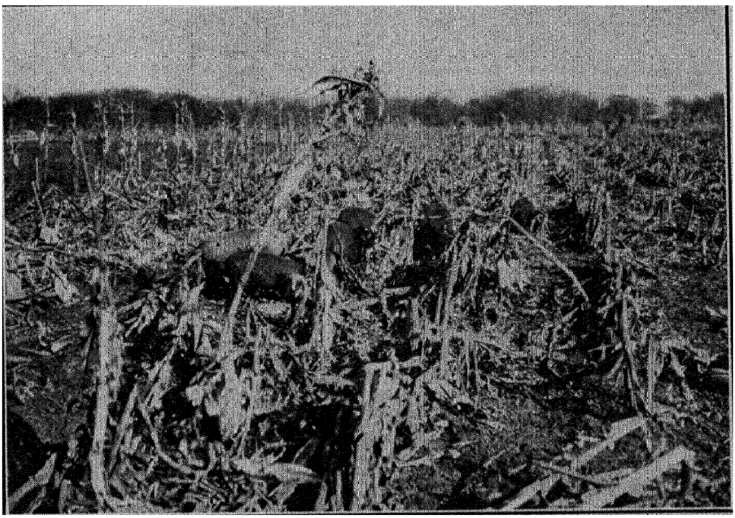


FIG. 13.—Hogging-down corn.

that shells the corn from the ear as a large wheel revolves the ear, so that the kernels are removed from the entire ear. Blowers for cleaning, cob stackers, and elevators are part of most of the power types. The cylinder sheller is usually a large power machine. The corn is shelled by the revolving of shelling rings within a cylindrical cage. A common objection to this type of sheller is that it breaks the cobs and cracks the kernels. Large shellers of this type can shell as many as 350 bushels in an hour, and handle "snapped" corn fairly well.

Harvesting with Livestock

Every year more growers are harvesting part of their corn crop with livestock. In Iowa one acre out of every fourteen is harvested with hogs. Corn growers should give serious attention to the possibilities of harvesting at least part of their crop with livestock.

There are three general ways of harvesting the standing corn crop with livestock, but hogging-down is the only common practice. These ways, in the order of their importance, are:

1. Harvesting with hogs—hogging-down.
2. Harvesting with sheep—sheeping-down.
3. Harvesting with cattle and horses.

Hogging-down.—Hogging-down corn is a practical and efficient way of gathering the crop and feeding spring pigs which are to be finished for the early winter market. Farmers who have tried it almost unanimously agree that the method is economical and successful. The most enthusiastic hogging-down men are those who have used the method longest. Tests show that hogging-down gives as good results as dry lot feeding.

Advantages of hogging-down, according to the Iowa station, are:

1. Labor is saved.
2. Storage charges on corn are saved.
3. The hogs develop good constitutions.
4. No manure is lost.
5. The manure is evenly and uniformly distributed.
6. The crop is harvested without waste.
7. The weeds may be cleaned up.
8. Fall plowing is sometimes possible.
9. Corn is harvested more quickly.

The practice has some drawbacks, however. The disadvantages, according to the Iowa station, are:

1. The process hardens the soil if pastured when wet.
2. Some waste of corn occurs in wet weather.
3. Fencing is difficult.
4. Brood sows and gilts become too fat.
5. Takes extra care to turn hogs into new corn.
6. Heavy hogs may waste some corn.
7. Hogs do not gain well after hogging-down.
8. There is likelihood of neglecting hogs.
9. Hogs are more liable to sickness.
10. Stalks are hard to plow under.

Variety of corn to use.—The highest yielding corn which is adapted to the locality is the variety to use for hogging-down. The hogging-down season may be lengthened by having a small field of an early variety of corn on which to turn the hogs early in the fall. In the North, hogging-down is the only practical way of harvesting short-stalked varieties such as the early flints. Sweet corn does not produce so much pork as field corn, because it does not yield so well.

Supplements necessary.—Hogs in the cornfield must have protein in addition to that furnished by the corn if they are to make the most rapid and efficient gains. The cornfield weeds, such as lamb's-quarter, pig-weed, morning-glory, etc., furnish a little bone and muscle-building material but not enough. Rape planted in the corn either at the time of the last cultivation or in the hill at corn-planting time furnishes enough growth when the season is favorable to supply part of the necessary protein. Soy beans planted with corn at corn-planting time usually increase the efficiency of the corn considerably. Tankage, however, seems ordinarily to be more effective and profitable than anything else in the production of rapid and economical gains on hogs in the cornfield. Experiments at the Ohio and Missouri stations indicate that it is almost as necessary to feed tankage to pigs on corn and soy beans as to feed it to pigs on corn alone. The following

table gives the average results of five years' experimenting at the Missouri station in the hogging-down of corn and of corn and soy beans, with and without tankage:

TABLE III

HOGGING-DOWN CORN AND SOY BEANS

(Average of five years' data—1919, 1920, 1921, 1922, 1923)

	Lot 1: Corn and Soy Beans (Supplemented by Tankage in Self-feeder)	Lot 2: Corn (Supplemented by Tankage in Self-feeder)	Lot 3: Corn and Soy Beans (with No Supplement)	Lot 4: Corn (with No Supplement)
Number of hogs per lot...	13 00	13.00	13.20	12 80
Length of feeding period (days)........ ...	21.07	22.00	21.42	22.56
Average initial weight (pounds)...	116.77	114 62	114 42	113 23
Average final weight (pounds)...........	153.59	154.54	137.38	134.75
Total gain (pounds)....	478.20	518.80	303.15	276.25
Average daily gain per head (pounds)	1.74	1.81	1.07	.95
Total feed consumed (pounds)—				
Corn................	1,703 50	1,949.90	1,694.60	2,138 00
Soy beans...........	247 20	....	248.40	
Tankage............	170 45	192.90		
Total.............	2,121.15	2,142 80	1,943.00	2,138.00
Average daily feed (pounds)—				
Corn................	6.21	6.81	5.99	7.40
Soy beans...........	.90	....	.87	
Tankage............	.62	.67		
Total.............	7.73	7.48	6.86	7.40
Feed per 100 pounds of gain (pounds)—				
Corn................	356.20	375.80	559.10	774.10
Soy beans...........	51.70	....	81.90	
Tankage............	35 60	37.20		
Total.............	443 50	413 00	641.00	774.10

It seems that farmers who will not feed tankage to their hogs in the cornfield will find it profitable to plant 3 or 4 pounds of soy beans per acre with their corn. If, however, they are prepared to feed from one-half to two-thirds of a pound of tankage per hog daily, there seems to be no gain from seeding soy beans with the corn.

At the Ohio station, as a three-year average, the following results were obtained:

TABLE IV

GAINS FROM ADDING SUPPLEMENTS TO STANDING CORN

	Standing Corn Containing Soy Beans	Standing Corn Containing Soy Beans Plus Tankage	Standing Corn Plus Tankage	Standing Corn Containing Rape Plus Tankage
Initial weight per pig (pounds)	147.50	147.60	146.90	147.30
Average daily gain (pounds)	1.08	1 73	1 78	1 88
Gain per bushel of corn (pounds)	8.89	13 23	12.62	12.89
Tankage with each bushel of corn (pounds)	....	2 29	2.83	2.06
Value of gains per bushel of corn with cost of tankage deducted	$ 0.62	$ 0.86	$ 0.80	$ 0.84
Yield of corn per acre (bushels)	52.60	52 60	57.30	56 80
Gross returns per acre with cost of tankage deducted	$ 32.74	$ 45.14	$ 45.75	$ 47 75

Gains in live weight valued at $7 per cwt. and tankage at $60 a ton. The yields of the soy beans were not determined. Comparable plots showed soy beans, grown in the corn, to have reduced the yield of corn 4.7 bushels, and rape to have reduced the yield of corn 0.5 bushel per acre.

Defenders of the soy bean now claim that when minerals are fed to hogs on corn and soy beans much better results will

be obtained. This has not yet been fully proved, but the one thing which stands out clearly is that fattening hogs in the cornfield must have tankage to give the most economical results, no matter what is planted with the corn in the way of soy beans or rape.

Other Essentials.—It is essential that the hogs be put on a full feed of corn before being turned into the cornfield. It is a good practice to feed green corn fodder with the old corn so that the hogs may become accustomed to their new ration. The feeding of oats will help to counteract the laxative effects of feeding the green corn. If the hogs come in to pens at night, some old corn should be fed to them before they are turned out in the morning.

Hogs do better when an abundance of water and shade are provided. Clean, clear tile water is good if the land from which it comes is free from cholera and other contagious infection. Clear creeks of known source and fresh springs are good drinking places for hogs. The ordinary barrel waterer works well in most places. The value of plenty of clean, fresh water for hogs in the cornfield can not be over-emphasized.

Carrying Capacity of Corn.—Usually the field should be fenced in such a way that small areas may be harvested at a time. It is well to hog-off an area in three weeks, and better in two weeks. Spring shotes weighing 90 to 130 pounds are desirable for hogging-down corn. According to the Minnesota station, the number of days required to hog off an acre of corn with 125-pound pigs is:

Number of Pigs Weighing 125 Pounds	Approximate Number of Days				
	30-bu.-per acre Corn	40-bu.-per acre Corn	50-bu.-per acre Corn	60-bu.-per acre Corn	70-bu.-per acre Corn
10...........	22.5	30.0	37.5	45.0	52.5
20..........	11 2	15.0	18.7	22 5	26.2
40.	5 6	7.5	9.3	11 2	14.1

Sheeping-down corn.—The practice of turning lambs into the cornfield at the rate of six or seven per acre, to clean up weeds and the lower leaves of corn, is a good one. Turning in twenty to forty lambs per acre to harvest the corn crop is more doubtful, for the reason that the lambs are ready to go back to market at the time when the fat lamb market is usually low, and, moreover, there is often some death loss when the lambs first begin eating corn.

FIG. 14.—Sheeping-down corn.

In the latter practice, all the essentials, such as providing proper forage, water, shelter, fencing, salt, the right kind of animals, and proper management, are similar to those for hogs and equally important. It is profitable to have additional pasture and forage outside of the cornfield for the lambs. Plenty of rough feed should be supplied so that the lambs will not eat too much corn. The same forages, soy beans, cowpeas or rape, as sown in the cornfield for hogs, may be used for sheeping-down. At the Nebraska station, it was found advisable to feed the average lamb in the cornfield one-fourth pound of oil meal daily.

Thrifty lambs, weighing from 45 to 60 pounds, are desirable animals for sheeping-down corn. Older sheep are all right if not too defective in the teeth to eat corn readily. The feeders should be started slowly on the corn to keep down scours and

bloat. Extreme precaution and common sense should be used in turning the lambs into the cornfield.

Lambs turned into the cornfield late in September will gain from 12 to 20 pounds per head in a feeding period of two or three months. During the feeding period the lambs will harvest 1 or 2 bushels of corn each, depending on the amount of supplementary feed. Small areas should be sheeped-down and the lambs moved before they have to hunt for feed. Shotes running with the lambs or turned into the field afterward will clean up the corn left by the lambs.

Harvesting with horses and cattle.—Horses and cattle may be used to harvest the corn from the standing stalks in the field. However, the disadvantages of packed soil, waste and fencing difficulties are more pronounced than in hogging-down. This method of harvesting is not a widespread practice, and is not used except for very cheap corn when husking is high-priced or labor is difficult to get. It is better to husk the corn fairly clean and turn in the horses and cattle to pasture the stalks and clean up the corn remaining in the field. A few farmers have claimed good results by turning hogs and cattle together into the cornfield. The cattle, in such cases, have been brought up to full feed before being turned in. After the cattle have cleaned up a little more than half of the corn, they are taken out and the hogs are left to clean up the rest. The cattle either are sent to market then or are kept on full feed for a short time and sent to market in early December.

Pasturing Cornstalks

A valuable by-product of the field-husked corn crop is the excellent pasture afforded by stalk fields after husking. A majority of Corn Belt farmers turn livestock into a cornfield as soon as the field has been husked. A stalk field furnishes a good place to winter over cattle and horses. The livestock

breaks down the stalks, aiding in preparation of the seed bed in the spring. Pasturing of stalks in wet weather is a disadvantage, however, especially on heavy soils, as the livestock pack down the soil.

SELECTED LIST OF REFERENCES

WEAVER, L. A. Hogging Down Corn and Soybeans. Mo. Bul. 224. 1924.

REYNOLDSON, L. A. Mechanical Corn Picker in the Corn Raising States. U. S. D. A. Yearbook. Pp. 521-22. 1926.

ROBISON, W. L. Hogging Down Corn. Ohio Bul. 398. 1926.

JOHNSTON, P. E., and MYERS, K. H. Harvesting the Corn Crop in Illinois. Ill. Bul. 373. 1931.

HOBSON, L. G., and WILEMAN, R. H. Mechanical Corn Pickers in Indiana. Purdue Bul. 362. 1932.

CHAPTER III

MARKETING CORN

EIGHTY-FIVE per cent of the corn crop is fed to livestock in some manner. In growing corn, therefore, it should constantly be kept in mind that livestock, in all probability, will be the final market. The outstanding problem of the Corn Belt is to obtain the greatest possible number of pounds of livestock from each acre of land at the least expenditure of human labor. Any step forward which results in the economic production of more bushels of corn per acre is fundamental to solving this problem.

The rich soil and favorable climate which make it possible to produce corn more abundantly and cheaply in the Corn Belt than any place else in the world, also make it possible for this section to produce fat livestock, especially hogs, more abundantly than any other part of the world. Fat, energy and heat-forming materials can be produced in corn of the Corn Belt with less outlay of man and horse labor than in any other grain.

LIVESTOCK USE OF CORN

Balancing the corn ration.—While corn is the most important fattening grain, it has certain serious drawbacks. First, it is low in protein and ash—bone- and muscle-building material. Second, the protein which it does contain is largely zein and other types of protein which are inefficient for muscle-building and milk-giving purposes unless properly supplemented with feeds containing higher types of protein. Third, corn is relatively low in vitamins except the B vitamin. Yellow corn contains a little A vitamin, but white corn contains none. At

the Wisconsin station it has been proved that on good pasture containing plenty of vitamin A pigs would gain as well on white corn as on yellow corn. Tankage usually contains a little vitamin A, but not enough to supplement the complete absence of this vitamin in white corn. This was indicated by a Wisconsin pig experiment in the fall in which it was found that the white-corn pigs during the winter required for 100 pounds of gain 489 pounds of white corn and 59 pounds of tankage, whereas the yellow-corn pigs required for 100 pounds of gain 439 pounds of yellow corn and 53 pounds of tankage.

Corn compared with other starchy grains.—The average percentage composition of some of the common carbohydrate grains, as given by Henry and Morrison, is given in Table V.

TABLE V

COMPOSITION OF ORDINARY CARBOHYDRATE GRAINS

Grain	Water	Ash	Crude Protein	Carbohydrates		Fat
				Fiber	N.F.E.	
Dent Corn No. 3	16.5	1 4	9 4	1 9	66 1	4 7
Wheat...	10.2	1 9	12 4	2 2	71 2	2.1
Oats	9 2	3 5	12 4	10 9	59 6	4.4
Barley......	9 3	2 7	11.5	4 6	69 8	2.1
Rye......	9 4	2 0	11.8	1 8	73 2	1.8

This composition shows that corn, wheat and rye each contain about 2 per cent fiber, whereas barley contains more than twice as much fiber as corn, and oats contain five or six times as much. In the case of hogs, each 1 per cent of excess fiber lowers the feeding value by 5 per cent. Fiber is not so important with horses and cattle, and for this reason oats are much more efficiently utilized by this class of livestock than by hogs.

Table VI, from "Feeds and Feeding," by Henry and Morrison, shows the average number of pounds of digestible

nutrients in 100 pounds and the nutritive ratio of the common grains:

TABLE VI

COMPARISON OF NUTRITIVE VALUE OF COMMON GRAINS

Grain	Total Dry Matter	Crude Protein	Carbo-hydrates	Fat	Nutritive Ratio
Dent Corn No. 3......	83.5	7.0	63 3	4 3	1 : 10.4
Wheat................	89 9	9 2	67.5	1 5	1 : 7.7
Rye..................	90 6	9 9	68 4	1 2	1 : 7.2
Oats.............	90 8	9.7	52 1	3 8	1 : 6.2
Barley..........	90 7	9 0	66.8	1 6	1 : 7 8

Grinding corn.—One great advantage of corn as a feed for hogs is that ordinarily it is not so necessary to grind it as is the case with most other grains. Numerous experiments have proved that with dent corn the most profitable results can usually be obtained in hog feeding with either ear corn or shelled corn. With flint corn, or even semi-flint corn, this is not true. At the Illinois station, for example, it was found that Democrat corn, which is classed as a dent, although it is harder than most dents, did not feed out nearly as well as Silver Mine corn. The hogs on the softer Silver Mine ate about a pound of corn more per head daily and required about 8 per cent less feed to produce 100 pounds of gain. Big hog raisers in Argentina have discovered that they could not build up a profitable hog industry there until they substituted the softer textured dents for the hard flints. In Europe the Argentine flint corn is always ground before feeding to hogs.

With fattening steers, the practical plan is to feed the corn on the ear or shelled if there are hogs following to pick up the corn, about 10 per cent of which passes through whole. With no hogs following, it is best to grind for fattening steers unless corn is exceedingly cheap. For milk cows, it almost invariably

pays to grind. Horses with ordinarily good teeth handle corn on the ear to the best advantage. Fattening lambs are usually fed shelled corn, although toward the close of the feeding period it may pay to grind.

In future corn breeding work, it will be well to remember that the ultimate destination of most of our corn is livestock, and that most of our corn is fed on the ear or shelled. Since 1915, there has been a tendency to breed for a horny kernel which is supposed to be associated with higher yield and disease resistance. It must also be remembered that this can be carried too far and that a flinty kernel will make it necessary to grind the corn.

Comparable values of Corn Belt feeds.—The following table gives the comparative values of corn and other feeds based on chemical analyses, when nitrogen-free extract (starch) is valued at 1 cent per pound, fat at 3 cents and protein at 5 cents per pound:

Grains	Value Per Bu.
Corn, No. 3	$0 71
Oats	0 43
Barley	0 64
Rye	0 77
Wheat	0 84
Soy beans	1 57

Commercial Feeds	Value per Ton
Bran	$29.38
Standard middlings (shorts)	31.75
Hominy feed	28.26
Linseed oil meal (old process)	45.54
Cottonseed meal (39 per cent)*	50 26
Corn gluten feed	38 26
Corn oil cake meal	38.28
Molasses feed (10 to 15 per cent fiber)*	25.30
Soy bean oil meal	53.06
Tankage (60 per cent)	65.58
Molasses (blackstrap)	16.20

*Cottonseed meal is actually worth only about 85 per cent as much as this chemical analysis value. Molasses feed and molasses are probably worth somewhat more than the values given because of a certain palatability which they possess.

Barley, wheat and rye, if they are to have a feeding value as high in relation to corn as indicated in this table, must be ground.

In years of short corn crops, it may be advisable to value the nitrogen-free extract at 2 cents a pound or even more, whereas protein may still be worth 5 cents a pound. It is necessary therefore, to re-calculate this table if it is to fit changing conditions from year to year.

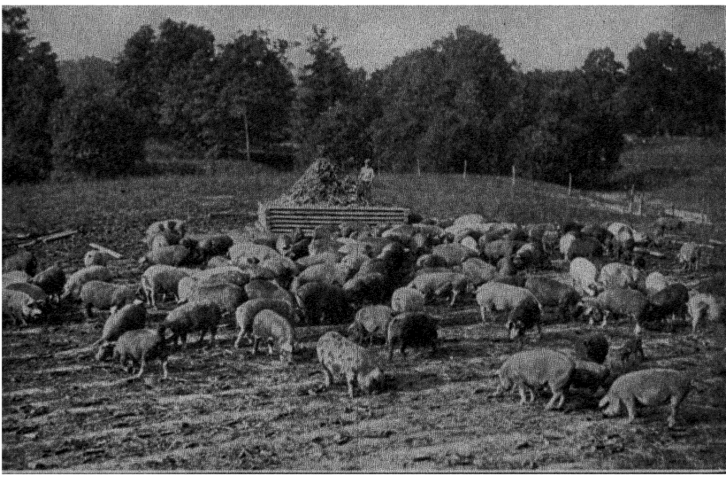


FIG. 15.—Half the corn of the Corn Belt is fed to hogs.

No animal can make satisfactory growth on corn alone. In the case of hogs, the bone- and muscle-building material in which corn is lacking may be supplied by small amounts of tankage, oil meal, dairy by-products, pasture, or alfalfa or clover hay. With cattle and sheep, oil meal, cottonseed meal, clover hay, alfalfa hay, or pasture most commonly supply the necessary protein and mineral matter.

Percentage of corn used by livestock.—Table VII indicates about what becomes of the corn crop in representative Corn Belt states:

TABLE VII

PERCENTAGE OF CORN CROP UTILIZED BY DIFFERENT ANIMALS*

	Iowa	Illinois	Nebraska	Indiana
Hogs	47	33	40	45
Cattle	16	13	13	14
Horses	7	15	14	13
Chickens	3	3	2	3
Shipped out (some of this is eventually fed to livestock)	27	36	31	25

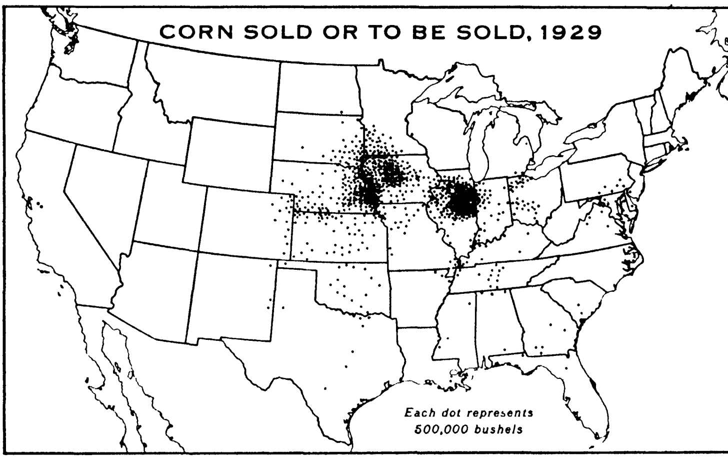
* In years of large corn crops and small hog population, the percentage utilization will be considerably different, but this table represents a fairly normal situation.

SELLING CORN AS GRAIN

About 250,000,000 bushels annually, or 15 to 20 per cent of the Corn Belt production, passes through such large primary corn markets as Chicago, Omaha, Peoria, Indianapolis, St. Louis and Kansas City. Chicago is outstandingly the largest of these primary markets, and normally receives over 100,000,000 bushels annually, or as much as any other four markets combined. Western Iowa, central Illinois and eastern Nebraska furnish over half of the corn which is received by the primary corn markets.

From farm to local elevator.—In northwestern Iowa, the typical method of handling the corn which is eventually sold at Chicago is described in the following: The farmer hauls his corn, either shelled or on the ear, to the local elevator. Most progressive farmers who have any large quantity of corn to sell prefer to shell at home, because they can haul a larger load of shelled corn. Moreover, they have the cobs to burn, and as a rule the elevator will pay them a cent or two a bushel more for shelled corn than for ear corn. The cost of hauling corn four or five miles is about four cents a bushel when man labor is 25 cents an hour and horse labor 13 cents an hour.

In November, December and early January, many elevators run a moisture test on the corn which they buy, especially in soft corn years. While the local elevators do not always buy corn on grade from the farmers, it is necessary at the start of each season for them to determine about how the typical corn in their respective communities will grade. If they find, as Iowa elevators found in December of 1917, that most of the corn is 22 to 26 per cent moisture, they know that



Courtesy of United States Department of Agriculture.

FIG. 16.—Most of the corn which comes on the terminal markets originates in central Illinois, northwestern Iowa and eastern Nebraska.

it will grade either as No. 6 or Sample grade on the Chicago market. They therefore pay the farmers the Chicago price for Sample grade corn minus freight to Chicago and the cost and risk of handling.

Price differential between corn on Iowa farms and at Chicago.—In the ordinary year, new corn in northern Iowa in December contains 18 or 19 per cent moisture, which permits it to grade as No. 4. As a rule, therefore, Iowa elevators during the early winter pay the Chicago price for No. 4 corn

minus freight and handling charges. The freight from north-central Iowa to Chicago previous to June 25, 1918, was about 7 cents a bushel. The rate was then raised until it reached 13 cents a bushel during the latter part of 1920 and during 1921. Since January of 1922, the freight has been 10.5 cents a bushel. It cost the ordinary country elevator about 3 cents a bushel to handle corn previous to 1917, and about 4.5 cents a bushel with costs as they have prevailed since 1922. This means that before the War the north-central Iowa elevator during the early winter usually paid the farmers for corn the Chicago price for No. 4 corn less 7 cents for freight and 3 cents for handling. In other words, with Chicago No. 4 corn at 60 cents a bushel, the north-central Iowa elevator paid 50 cents.

In the summer-time, when the moisture content in farm corn dropped to less than 15.5 per cent and the corn would therefore grade as No. 2 instead of No. 4 on the Chicago market, the north-central Iowa elevator would pay the farmers about 10 cents below the Chicago price for No. 2 corn. Since 1922, the standard differential between Chicago corn prices and prices paid by north-central Iowa elevators has been 10.5 cents (the freight rate) plus 4.5 cents (the handling charge), or a total of 15 cents. In December and January of many years, much of the new corn in the country grades No. 4 or even lower, and the prevailing farm price will be, under freight and handling charge conditions as existing since 1922, the Chicago price less about 18 cents.

In recent years there has been a tendency for the Chicago corn market to decline somewhat in relative importance. More and more corn is being moved direct across country without passing through the Chicago market. Such small markets as Cedar Rapids, Des Moines and St. Joseph have been growing. In the old days it was necessary to have grain pass through Chicago in order to have grades and weights certified to in a way which would command confidence in the minds of the consumers. To-day, very small markets can certify properly as to grades and weights. As a result of the development of other

markets than Chicago, there is an increasing tendency for corn on Iowa farms at times to sell above a parity with the Chicago market. In times of a short crop in the southwest, Iowa corn prices may even be temporarily within 8 or 10 cents a bushel of Chicago.

Types of country elevators.—There are three kinds of country elevators—independent, line and farmers' co-operative. The independent elevator is usually owned by a wealthy man in a small town who has an extensive acquaintance with farmers. Bankers, lumber dealers and feed dealers seem especially likely to embark on this line of business.

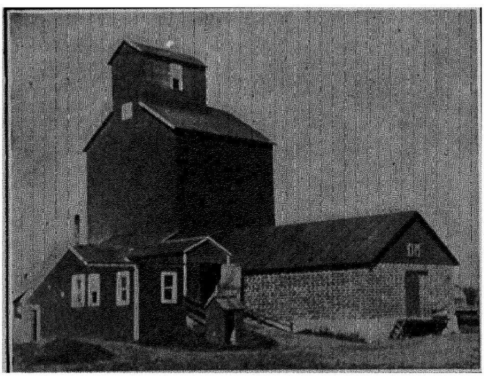


Fig. 17.—Typical country elevator.

The Federal Trade Commission reports that of over 9000 concerns handling grain at country stations in 1918, from which reports were secured, 36 per cent were commercial line elevators, 19.49 per cent were farmers' co-operatives, and 31.62 per cent were commercial independents. The local mills accounted for most of the balance. In several of the grain states, where there is a keen interest in co-operative marketing, the percentage of farmers' elevators is much higher than the general average of the country as reported by the Federal Trade Commission. For instance, Iowa's percentage of co-operative elevators was estimated at 32.6 in 1921. It should be noted also that the average farmers' elevator does business on a bigger scale than either of the other types. It buys annually on the average nearly twice the volume of the line elevator and about one-half more than the average independent. Ordi-

narily, an elevator should handle 100,000 bushels of grain annually if it is to do business on an economical basis.

Previous to 1900, many of the line elevators profiteered unmercifully, at the expense of their farmer patrons, and did all in their power to prevent the formation of co-operative elevators. Since 1910, the different types of elevators seem to have been doing business on about the same margin, with the tendency in favor of the co-operative elevators in years of rising prices, and oftentimes in favor of the line or independent elevators in years of falling prices.

Two ways in which country elevators may sell grain at Chicago.—Country elevators may ship their grain to Chicago as fast as they are able to fill the cars, or they may ship a little more leisurely and protect themselves against a decline in the market by "hedging" (selling short as many bushels of corn for future delivery as they have bought from the farmers). If the elevator does not take out any price insurance in the form of "hedge" sales, it will make a speculative profit above expectations in case the Chicago market advances before the car gets to it. On the other hand, there may be a speculative loss if the market falls. This speculative risk becomes very great in years of car shortage, which may cause the lapse of several weeks between the time the corn is purchased from the farmer and the time it is sold at Chicago.

When an elevator deals only in cash grain without any "hedge" insurance, it is necessary to pay $18 to $24 a car (1 to 1.4 cents per bushel) for brokerage and miscellaneous charges. If, however, an elevator takes out "hedge" insurance by selling "future" corn at the time the purchase is made from the farmers, it is necessary to pay about one-fourth of a cent per bushel in addition for the insurance.

The method of hedging is illustrated in the following: An elevator is buying corn on February 20, which it expects to ship some time in March. May future corn, which is the nearest future, is quoted at 72 cents, and the cash No. 3 corn is 66 cents. The elevator must purchase corn from farmers at

15 cents below Chicago price for the same grade, and it therefore pays 51 cents for 1115 bushels of corn, which is all that is offered to it that day. The same day it wires a commission company at Chicago to sell 1000 bushels of May corn at 72 cents (the 6-cent difference between the February cash No. 3 corn price and the May future is in part caused by contract future corn being No. 2 and in part by the two or three months' storage charges). When the corn is finally received in Chicago, on March 10, the price of the May future may be 65 cents and the cash No. 3 corn 59 cents. In that event, the elevator, in buying back its paper contract on March 10, makes a profit of seven cents a bushel, which enables it to meet the loss on the cash corn. On the other hand, an advance to 80 cents for May future and 74 cents for No. 3 cash will result in a loss of 8 cents a bushel on the paper corn, which counterbalances the gain of 8 cents on the actual corn. In either case, the net result is that the elevator gets for its corn a price about equivalent to what it paid the farmers on February 20.

On the average, the present-day capacity of a car of corn moving from Iowa to Chicago is about 1600 bushels. This capacity introduces another factor from the standpoint of hedging to which the country shortly must give consideration inasmuch as the minimum future trade that can be executed is 1000 bushels. From the standpoint of shipment there is considerable overage, and the elevator using the futures market for hedging must therefore be overhedged or underhedged. For example, if the car contains 1600 bushels the elevator must carry a hedge either for 1000 or for 2000 bushels.

The theory of "hedging" is attractive, and the practice is fairly good. Unfortunately, some elevator managers succumb to the temptation to buy and sell paper grain above what is needed for purely "hedging" purposes. In a few cases, also, the cash grain and future grain markets do not maintain the

sympathetic relation toward each other which is necessary if "hedging" is to be perfect price insurance.

The four futures commonly dealt with on the Chicago market are May, July, September and December. The smallest unit of paper grain customarily handled is 1000 bushels. Commission firms charge one-fourth of a cent per bushel, or $2.50 for 1000 bushels, for the sale and purchase. In addition, it is necessary to put up with commission firms about 6 cents a

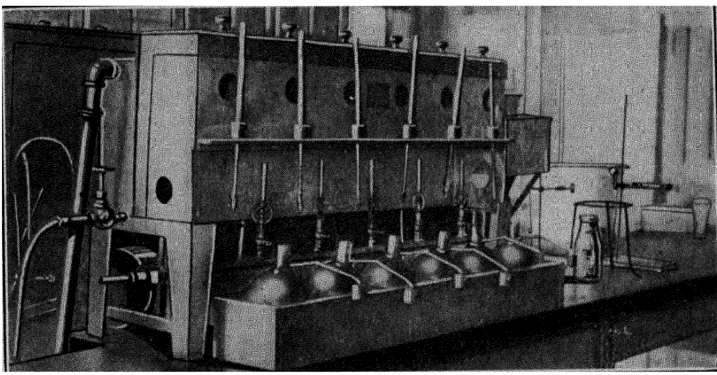


FIG. 18.—Moisture tester used in determining corn grades, both by country elevators and at primary markets.

bushel, or $60 for 1000 bushels, to serve as margin to protect the commission company if the corn goes up before the deal is closed. "Hedging" can be made really useful by elevator managers, especially when they are unable to ship promptly and when the tendency of the market seems downward. In the case of line elevators, "hedging" is usually taken care of from a central office. Many co-operatives do not hedge at all, partly because they fear their managers may speculate on the side and partly because they do not understand the advantages.

The Grain Futures Act, which was passed by Congress in 1922, gave the United States Department of Agriculture power

to designate certain markets as contract markets where futures might be traded in. Regulations could also be prescribed with the idea of making it possible for the future grain prices to register actual changes in supply and demand conditions rather than mere speculative raids and corners. The Act was designated to make it possible to use the Chicago market for "hedging" purposes with greater safety than would otherwise be the case.

In June, 1936, the Commodity Exchange Act was passed. The Grain Futures Act is amended and now comes under this new title. This Act contains a number of new provisions from the standpoint of the country shipper who uses the futures market for hedging purposes. One of the most important is the provision which requires commission houses to handle customers' margin money with considerable more care than heretofore. Commission firms are specifically prohibited from commingling such margin money with their own funds; neither can they use any part of the margin money of any one customer to extend credit to any other customer.

Handling cash grain at Chicago.—Grain cars, when they reach Chicago, are switched onto grain tracks, where they are examined by state grain inspectors. Samples of grain are secured from each car and taken to a grain grading room where the percentage of moisture is ascertained and the corn is given a definite grade on the basis of the Federal Official Grain Standards, as set forth in Table VIII.

TABLE VIII

STANDARDS FOR CORN*

For the purposes of the official grain standards of the United States for corn (maize):

Corn.—Corn shall be any grain which consists of 50 per cent or more of shelled corn of the dent or flint varieties, and may contain not more than 10 per cent of other grains for which standards have been established under the provisions of the United States Grain Standards Act.

* The specifications of these standards shall not excuse failure to comply with the provisions of the Food and Drugs Act.

Classes.—Corn shall be divided into three classes, as follows: Class I, Yellow Corn; Class II, White Corn; and Class III, Mixed Corn.

Yellow Corn (Class I)

This class shall include Yellow Corn, and may include not more than 5 per cent of corn of other colors. A slight tinge of red on kernels of corn otherwise yellow shall not affect their classification as Yellow Corn.

White Corn (Class II)

This class shall include White Corn, and may include not more than 2 per cent of corn of other colors. A slight tinge of light straw color or pink on kernels of corn otherwise white shall not affect their classification as White Corn.

Mixed Corn (Class III)

This class shall consist of corn of various colors that does not meet the color requirements for either of the classes Yellow Corn or White Corn. White-capped yellow kernels shall be classified as Mixed Corn.

Grades.—Corn shall be graded and designated according to the respective grade requirements of the numerical grades and Sample grade of its appropriate class, and according to the special grades when applicable.

Corn

Grade requirements for Yellow Corn, White Corn, and Mixed Corn

Grade No.	Minimum test weight per bushel, Pounds	Maximum limits of—			
		Moisture, Per Cent	Cracked corn and foreign material, Per Cent	Damaged kernels	
				Total, Per Cent	Heat-damaged, Per Cent
1	54	14.0	2	3	0.1
2	53	15.5	3	5	.2
3	51	17.5	4	7	.5
4	48	20.0	5	10	1.0
5	44	23.0	7	15	3.0
Sample grade.	Sample grade shall include corn of the class Yellow Corn, or White Corn, or Mixed Corn, which does not come within the requirements of any of the grades from No. 1 to No. 5, inclusive; or which contains stones and/or cinders; or which is musty, or sour, or heating, or hot; or which has any commercially objectionable foreign odor; or which is otherwise of distinctly low quality.				

Special Grades for Corn

Flint Corn

Definition.—Flint corn shall be corn of any class which consists of more than 25 per cent of flint corn.

Grades.—Flint corn shall be graded and designated according to the grade requirements of the standards applicable to such corn if it were not flint corn, and the word "Flint" shall be added to, and made a part of, the grade designation, immediately following the word Yellow, or White, or Mixed, as the case may be.

Weevily Corn

Definition.—Weevily corn shall be corn that is infested with live weevils or other insects injurious to stored grain.

Grades.—Weevily corn shall be graded and designated according to the grade requirements of the standards applicable to such corn if it were not weevily, and there shall be added to, and made a part of it, the grade designation, the word "Weevily."

Definitions

Basis of grade determinations.—Each determination of class, variety, damage, and heat damage, shall be upon the basis of the grain after the removal of the cracked corn and foreign material. All other determinations shall be upon the basis of the grain as a whole.

Percentages.—Percentages, except in the case of moisture, shall be percentages ascertained by weight.

Percentage of moisture.—Percentage of moisture shall be that ascertained by the water oven and the method of use thereof described in Service and Regulatory Announcements No. 147 of the Bureau of Agricultural Economics of the United States Department of Agriculture, or ascertained by any device and method which give equivalent results in the determination of moisture.

Test weight per bushel.—Test weight per bushel shall be the weight per Winchester bushel as determined by the testing apparatus and the method of use thereof described in Bulletin No. 1065, dated May 18, 1922, issued by the United States Department of Agriculture, or as determined by any device and method which give equivalent results in the determination of test weight per bushel.

Cracked corn and foreign material.—Cracked corn and foreign material shall include kernels and pieces of kernels of corn and all matter other than corn which will pass through a No. 12 sieve, and all matter other than corn remaining on such sieve after screening.

No. 12 sieve.—A metal sieve perforated with round holes 12/64 inch in diameter.

Other grains.—Other grains shall include wheat, rye, oats, grain sorghums, barley, hull-less barley, flaxseed, emmer, spelt, einkorn, Polish wheat, poulard wheat, cultivated buckwheat. sweet corn, pop corn, and soy beans.

Damaged kernels.—Damaged kernels shall be kernels and pieces of kernels of corn which are heat damaged, sprouted, frosted, badly ground damaged, badly weather damaged, or otherwise materially damaged.

Heat-damaged kernels.—Heat-damaged kernels shall be kernels and pieces of kernels of corn which have been materially discolored and damaged by external heat or as a result of heating caused by fermentation.

Utilizing Soft-corn Crop

Handling soft corn is a serious problem over large sections of the northern part of the Corn Belt, in such years as 1902, 1915, 1917, and 1924. Bad soft-corn years are foreshadowed long in advance by cold, wet summer weather. After a summer of this sort, it is only rarely that dry, warm weather in September and October will avert the threatened danger.

In the typical soft-corn year at the time of the first killing frost in late September or early October, about one-fourth of the ears will be in the milk stage, containing about 60 per cent moisture; one-fourth will be rather soft but somewhat dented, containing 45 to 55 per cent moisture; one-fourth will be well dented, but rubbery, containing 40 to 45 per cent moisture; and one-fourth will be solid, well-matured ears, containing 30 to 40 per cent moisture. In the ordinary season, the last two classes, containing 30 to 45 per cent moisture, will be down to less than 25 per cent moisture by Thanksgiving time, and can be cribbed with safety. Corn which is doughy or milky, however, at the time of the first killing frost, dries out very slowly unless October and early November are unusually dry and warm. Ordinarily, this doughy or milky corn still contains 25 to 35 per cent moisture in late November or early December. By that time it will have become dented and somewhat chaffy as a result of partial drying, but it will still contain too much moisture as a rule to keep without molding, heating or discoloration when stored in the ordinary crib.

Cribbing soft corn.—Farmers prefer to store most of their corn in the crib if it is at all practicable. They know that in a soft-corn year about half the ears will heat and mold if put into the ordinary crib at husking time in November. To get around the difficulty, they use various devices. First, many of them divide their wagon box, when husking, into two parts and throw the soft corn into one part and the cribbable corn into the other. Others vary this plan by making the separation into soft and cribbable corn at the crib at the time the

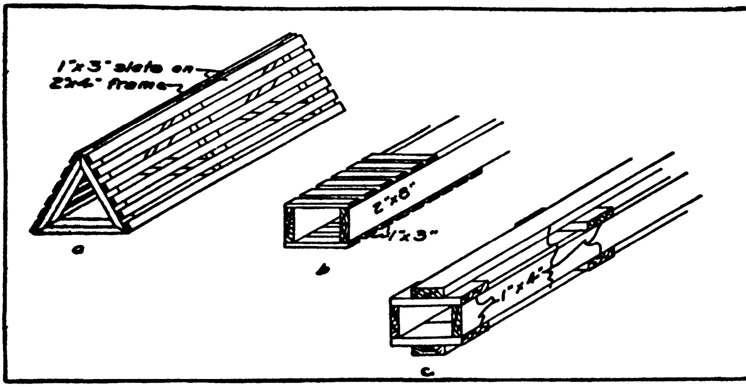


FIG. 19.—Crib ventilators of this type can be used in either a vertical or a horizontal position in the crib.

wagon is being unloaded. When this plan is followed, the soft corn is fed out or sold in a few weeks. Second, many farmers put extra ventilators into their cribs. Strings of 6-inch tile laid every 2 or 3 feet crosswise of the crib answer the purpose very nicely. Other types of ventilators are suggested in the accompanying illustration from Illinois Circular No. 293. Two ventilators of the sort illustrated are usually laid horizontally after about 2 feet of corn have been put in the crib, and then after about 2 feet more of corn have been spread two more ventilators are put in, and so on. Some farmers make vertical ventilators somewhat resembling chimneys, by using 2 × 4's about a foot apart each way and connected with 1 × 3 slats.

These vertical shafts are sometimes connected up with horizontal strings of tile. The idea in any scheme of ventilation is to have all of the corn within at least 2 feet of the air.

A third plan is salting. This has been used by a number of farmers in Illinois. Tests by Hughes, of the Iowa station, indicate that 1 pound of salt per hundred bushels of corn helps considerably in reducing mold in corn which contains 30 per cent moisture at cribbing time. Two pounds of salt per 100 bushels are more effective, but such heavy salting is not wise when the corn is to be fed to livestock. Salting should always be used in connection with one of the ventilating devices as is described in the foregoing. The method of salting is to spread a layer of salt with each 1½ foot layer of corn. Hughes has also proved that salting is valuable in preventing heating in shelled corn containing 30 per cent moisture. With both salting and ventilation of cribbed corn, it is a help if the corn is husked cleaner than usual, with the minimum of husks and silks.

A fourth plan, much used by practical farmers, is to delay cribbing in a soft-corn year until the late winter. The ordinary winter allows the soft corn to dry out very nicely on the stalk. In 1917, a number of farmers followed this plan, husking their corn as they needed it, and storing only a rather small quantity of corn in the crib at the regular time in November. Farmers who husked in March of that year claimed that their soft corn was so well dried out that it kept perfectly through the summer in the ordinary crib without any special ventilation.

Shocking soft corn.—With the corn binder it is possible to cut up about eight acres a day, and in a soft-corn year, the average farmer with forty to sixty acres of corn and fifteen to twenty cattle will find it worth while to cut up fifteen or twenty acres, or even more, if he has no silo. In a soft-corn year the stalks contain a higher percentage of the food value than ordinarily. The shocks should be made a little smaller

than usual in a soft-corn year in order to permit more rapid drying.

Siloing soft corn.—For the man who has livestock, the silo is the ideal place to store soft corn. On most farms, however, the silo will hold only about one-fourth the crop. One way around the difficulty is to refill the silo in January or February with dry corn fodder, adding 100 pounds of water for each 100 pounds of dry fodder. This plan is not satisfactory if delayed until early spring. Another method of increasing the holding capacity of the silo in a soft-corn year is to put into the silo only the snapped ears. About twice as many acres of snapped corn can be put into the silo as of ordinary silage corn. Feeding tests at both the Iowa and Illinois stations have demonstrated that silage made out of either snapped soft corn or husked soft corn is of high feeding value. The greatest drawback of this plan is that the feeding value of the stalks is lost to a considerable extent, and this is a serious loss because in a soft-corn year the stalks are of higher feeding quality than usual. Practical farmers have been slow to follow the practice of siloing soft ear corn in spite of the favorable experiments at the Iowa and Illinois stations.

Shredding.—Shredding soft corn is usually unsatisfactory. It is hard to shred because it is sappy, and, furthermore, if it is not well dried out it will spoil in storage. Some farmers recommend the addition of salt, about 5 to 20 pounds to the ton. If necessary to shred, it is well to shred often, and not store too large a quantity of shredded material. It is well to put off the shredding to the latest possible date, so that the corn will be well dried out in the shock.

Use of heat.—Soft corn has been dried out in the crib at a low cost by a method originated by the Iowa station. Ventilators are placed underneath a crib and heat is forced through the corn by means of a hot-air furnace and blower. A series of trap doors allows drying out of small sections of

the crib at one time. In tests, the moisture content of crib corn was reduced from over 30 per cent to less than 10 per cent, at a cost for fuel and power of less than 5 cents a bushel.

This plan of forcing heated air through the corn in the crib has not come into extensive use because of the large investment in the furnace and because ordinarily a really calamitous soft-corn year necessitating such expensive apparatus, if the corn is to be kept in the crib, comes only about once in ten years. Farmers in the northern part of the Corn Belt, who grow over 100 acres of corn and sell a high percentage of their crop on the market, will find it worth while to look into this Hughes plan of hot-air drying. Most farmers will not find it practicable.

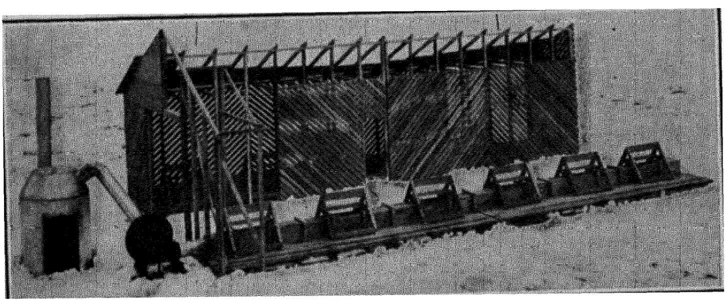


FIG. 20.—Model of the Hughes hot-air drier, which has been used very successfully in making soft corn cribbable.

Marketing.—In marketing soft corn, it is well to shell and haul to market in the frozen state. Inasmuch as a premium is paid for the most mature, hardest corn, it is well to sell that and feed the soft ear corn. It is surprising how much water in a frozen condition ear corn can carry in the grain. Even though not frozen, corn with as much as 25 per cent moisture shells readily.

Feeding.—Feeding soft corn is the most logical method of disposition. There are two essential precautions: Feed early while the quality is still good, and feed often—three, four and more times a day. Moldy corn is dangerous for horses and young sheep. But hogs may usually be trusted to eat what they will.

"Moldy corn," says Dr. R. E. Buchanan, "has often been suspected of poisoning cattle and hogs. Investigations carried on in recent years seem to indicate, however, that this rarely, if ever, occurs. The diseases or sicknesses of cattle which once were supposed to be due to mold poisoning have since been found to be due to infection with hemorrhagic septicemia or other diseases which have nothing whatever to do with mold on corn. It seems, therefore, that there is no good reason why corn showing more or less mold can not safely be fed to cattle and hogs.

"The molds which appear are sometimes blackish, sometimes bluish, greenish or pinkish in color. If these molds are not present in excessive amounts, that is, if the corn is not actually rotten or matted together by the mold, it is not probable that cattle and hogs will be injured by eating it.

"What has been said above, however, should not be used as justification for feeding moldy corn to horses. Many instances are on record of horses being killed by eating moldy silage, moldy corn, and moldy forage of other types. Whether or not it is the mold itself or some other organism growing in the moldy corn that causes the trouble is at present uncertain."

Evvard found at the Iowa station that with soft corn containing 25 per cent moisture hogs required for 100 pounds of gain 495 pounds of soft corn and 47 pounds of tankage, whereas the same kind of hogs fed at the same time with old corn containing 14 per cent moisture, required for 100 pounds of gain 432 pounds of old corn and 34 pounds of tankage. The dry matter in soft corn has about the same chemical composition

as the dry matter in old corn, but for some reason animals fed on soft corn crave more protein than animals fed on sound corn. It seems to be wise, therefore, to feed a little more tankage than usual to hogs on soft corn and a little more oil meal than usual to cattle on soft corn.

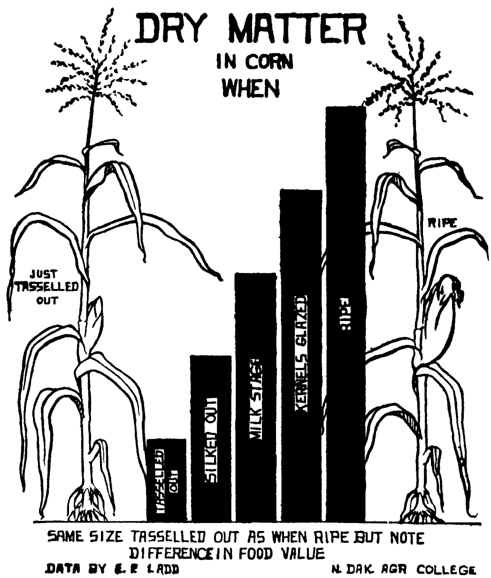


FIG. 21.

Buying soft corn.—The feeder who has a choice between buying No. 2 or No. 3 corn, containing 15 to 18 per cent moisture, and soft corn of sample grade, containing over 23 per cent moisture, oftentimes does not know what to do, especially when he can buy the soft corn at 20 cents a bushel less. A safe guide is to figure out the cost of a pound of dry matter in the two grades and then to choose the high-grade corn unless a pound of dry matter can be bought in the soft corn for less than 90 per cent as much as in the sound corn. If the soft corn is moldy or discolored, it should not be bought unless a pound of dry matter can be bought in it for less than 80 per cent as much as in the sound No. 2 or No. 3 corn. In fact, there are some grades of soft corn which are practically worthless, even after their high moisture content is taken into account. Ordinarily, however, soft corn containing 25 per cent moisture, which is

not moldy or discolored and which can be fed out before there is any danger of spoiling, is worth to the feeder about 80 cents a bushel on the basis that No. 2 corn is worth $1 a bushel.

Chemical analysis of corn at different stages.—The yield of dry matter in corn at different stages, on the acre basis, as figured from Indiana results of Jones and Huston, on a basis of 100 as final mature yield, is given in Table IX.

TABLE IX

YIELD OF DRY MATTER IN CORN AS RAISED IN INDIANA

Stage of Growth	Corn Plus Cob (Ear)	Stalks, Blades, Husks, etc.—Stover	Entire Corn Plant
Four feet high	....	....	7 76
First tassels	....	....	23.85
Silks drying, kernels forming	14.56	90.21	48.53
In the milk	43 73	92.41	65.59
In the glaze	74 56	100.00	86 11
Well dented	89.19	101.84	94 87
Ready to shock	100.00	100.00	100.00

In the early kernel stage, less than 15 per cent of the dry matter found at maturity has been laid down in the ear, and only 44 per cent in the milk stage. If frost comes when the milk still shows plainly, the yield is approximately half in dry matter, as compared to the normal matured yield. The stover contains more than 90 per cent of the total possible dry matter as early as the milk stage. Therefore, in frosted corn the greatest damage in yield is to the ears.

SELECTED LIST OF REFERENCES

Evvard, John M. The Soft Corn Problem. Iowa Circ. 40. 1917.

Rickey, L. F. Costs of Storing Corn on the Farm. Ill. Bul. 295. 1927.

Cox, R. W. Factors Influencing Corn Prices. Minn. Tech. Bul. 81. 1931.

Shepherd, G. S. The Secular Movement of Corn Prices. Iowa Res Bul. 140. 1931.

Anonymous. Corn Futures. U. S. D. A. Statistical Bul. 34. 1931.

CHAPTER IV

TESTING, GRADING AND ADAPTING SEED CORN

IF seed corn is picked before freezing weather and stored in a dry, well-ventilated place and protected from freezing temperatures until it is well dried, there is no need of seed-corn testing. But in order to be absolutely safe, every farmer, in February, should germinate two hundred kernels of corn from two hundred ears taken at random. If less than 90 per cent of these kernels grow strongly, it will almost certainly pay the farmer a dollar an hour for his time to make a thorough ear by ear test of all the ears which he expects to plant.

RAG DOLL TEST

The cheap and efficient rag doll.—The rag doll seed corn germinator, according to Hughes, of Iowa, made possible a satisfactory corn crop throughout all of the Corn Belt in 1918, when we were at war and when a failure in our corn crop would have been a national disaster. Seed corn fit to plant was not to be had in any quantity, perhaps not enough to plant one-tenth of the corn crop. The only means of getting good seed was by testing millions of individual ears, separating the good from the bad. The doll germinator was used in making practically all of these tests.

The ear-by-ear test may be made easily with the rag-doll tester, which is the simplest of all the home-made testers. To make and fill a forty-ear rag-doll tester:

1. Tear sheeting into strips 12 inches wide and 60 inches long.
2. Spread the cloth lengthwise on table and rule through the middle

and crosswise every 3 inches, leaving 5 inches on each end. This makes twenty squares on each half of the doll.

3. Number the squares, with "1" in upper left-hand corner, "2" in upper right-hand corner, "39" in lower left-hand corner, "40" in lower right-hand corner.

4. Write numbers corresponding to the forty ears being tested on the back of the left-hand end of the cloth.

5. Thoroughly wet the cloth and spread it smoothly on the table, with Square No. 1 at the left.

6. Remove six kernels from representative parts of Ear No. 1 and place in Section No. 1 of the cloth; and so on for the forty ears.

7. Use a stick or roll of paper the diameter of a pencil, around which to roll the cloth.

8. Roll the cloth carefully, but not too tightly, beginning at the right-hand end.

9. Place a cord or rubber band loosely around the middle and firmly around each end of the rag doll.

10. Soak in lukewarm water for five to ten minutes.

(See page 145 for description of use of rag doll in eliminating moldy and diseased ears.)

After soaking, turn a bucket upside down over the dolls, keeping them from drying out while the kernels are given time to germinate. If placed in a pail, the dolls should be raised so that the lower end will receive sufficient air and not stand in the water. If the dolls are stood up, the sprouts will grow toward one end and the roots toward the other, making the test much easier to read than where the dolls are allowed to lie flat. This method also insures better drainage and better ventilation. It is also well to put a wet piece of gunny sack or other coarse cloth around the dolls to prevent them from drying out. The dolls should be sprinkled often enough to keep them moist. They should be kept at room temperature, 60 to 80° F. The end bands should be removed after two days, to allow sufficient room for growth. In five or six days, the germination test should be ready to read.

To read the test, carefully unroll the doll. Examine all kernels closely. In case all six kernels do not show strong germination, the ear should be discarded. There is danger of

discarding as worthless, however, ears called "slow germinators," which, though backward in germination, are practically as strong as any. At the Iowa station, ears which when tested and read as having six weak kernels, gave a higher stand and a greater yield in tests than any other class of ears with the exception of those read as six strong. If seed is very scarce, it may be well to save ears showing not more than one dead kernel out

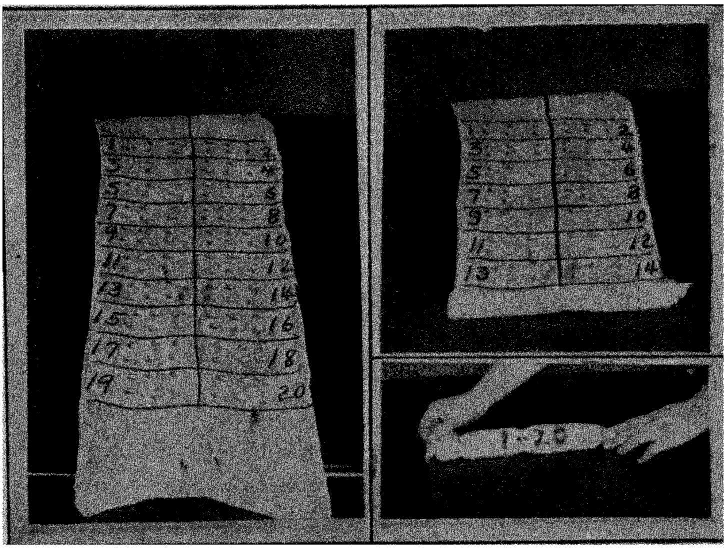


FIG. 22.—Rag doll seed-corn tester.

of the six tested. Table X gives the stand and yield obtained by the Iowa station when ears of different germinating power were planted in separate plots, but under the same soil and climatic conditions:

On the basis of this experiment, we would expect corn, which in the preliminary 100-kernel test stood 57 strong, 37 weak and 6 dead, to yield about 43 bushels per acre, as compared with 45.7 bushels for really strong corn. Incidentally, it should be stated that in 1911 the weather was exceptionally warm in

May, June and July, and thus favored low-testing corn more than usual. In 1910, when this same experiment was conducted the weather in May and June was very cold and the margin in favor of the high-testing ears was much greater than in 1911. In the ordinary season it is safe to say that ear-by-ear seed-corn testing pays at the rate of at least one dollar an hour unless the preliminary test indicates that 90 out of each 100 kernels will grow strongly and that not more than six out of the 100 are dead.

TABLE X

STAND AND YIELD TESTS OF CORN FROM SELECTED SEED EARS IN IOWA

Average of Two tests by Iowa Station in 1911.

Germination			Stand Per Cent	Yield Bushels
Strong	Weak	Dead		
6	0	0	73 9	45.7
5	0	1	66.4	43.4
4	0	2	59.4	41.0
3	0	3	53.2	37.6
2	0	4	43.0	32.2
5	1	0	70.4	44.4
4	2	0	68.6	44.0
3	3	0	68.2	43.6
2	4	0	64.1	41.4
1	5	0	68.0	44.1
0	6	0	71.0	44.8

Cost of testing.—The cost of testing individual ears of corn for germination depends upon the method used and the efficiency of the operator. From the tests made at the Iowa experiment station, the cost has been found to be from 15 cents to 45 cents for each one hundred ears. The difference was due entirely to the method of testing which was employed. The cost of testing corn by the rag-doll method was 18 cents and by

the sawdust box method, 27 cents. This was on the basis of pre-war values.

The cost of selecting seed for planting an acre will depend upon the method used and the quality of the corn. If the corn is of fair quality so that it is not necessary to throw away too many ears, the testing cost per acre will be less than 10 cents. And even if the corn is of such poor vitality as to make it necessary to throw away 85 per cent of the ears, the total cost of getting out enough for an acre will not be over 25 cents.

What to do if low-testing corn must be planted.—Even though corn with a general test as low as 60 per cent must be planted, the effect on the yield is not necessarily very serious, provided the farmer knows that he is planting low-testing corn and increases his rate of planting accordingly. If the farmer would plant 100 per cent corn at the rate of three kernels per hill, he should plant 60 per cent corn at the rate of five kernels per hill in order to get as many live kernels planted on each acre as with good corn. According to the theory of probabilities, 17,500 kernels of 60 per cent corn planted on an acre of 3500 hills would result approximately in:

36 hills with 5 dead kernels.
272 hills with 5 live kernels.
907 hills with 1 dead and 4 live kernels.
269 hills with 4 dead and 1 live kernel.
1,210 hills with 2 dead and 3 live kernels.
806 hills with 3 dead and 2 live kernels.

If the live kernels from 60 per cent corn grew as vigorously as from 100 per cent corn, the yield should not be affected by more than two or three bushels per acre by such a distribution as the above. At any rate, at the Nebraska station, as a five-year average, it was found that alternating hills of one, two, three, four and five plants yielded at the rate of 58.6 bushels per acre, as compared with 59 bushels where every hill contained three plants. One of the greatest objections to planting 60 per cent seed corn is that the hills with four to five stalks have a rather high percentage of nubbins. Of course the plant-

ing of poor seed corn thickly is attended with considerable risk, and this plan should never be followed unless the only alternative is buying unacclimated seed. It is better to plant home-grown seed corn of low-germinating power thickly than it is to buy high-germinating corn from a distance.

Shelling and grading seed corn.—Ideally, each ear should be shelled by hand, each ear going into a pan by itself before it is dumped into the sack with the rest of the corn. In this way, ears with moldy and dull, starchy kernels may be detected and thrown out. Ears with blistered germs and shrunken kernel tips can also be thrown out. If the job of shelling seed corn by hand is done conscientiously, it is easily possible to earn wages of one dollar an hour, and especially is this true if the corn has not been given a careful ear by ear germination test. Experiments at Ames indicate that it is much easier to judge the yielding power of an ear of corn by looking at its shelled kernels than by looking at the ear itself. Shelling corn by hand gives the time required to judge kernel type effectively. It may also avoid a few broken kernels, but this is not at all important. In fact, experiments reported by Bulletin No. 1011 of the United States Department of Agriculture indicate that corn kernels will stand an astonishing amount of mutilation and still grow fairly normally.

After shelling, it helps a little to run the corn over either a cheap hand grader or a cylinder machine grader. Iowa experiments indicate that size of kernel is one of the most important things in determining yield. The light, small kernels are often poor yielders. Theoretically, therefore, the eliminating of the small kernels with a grader should be decidedly worth while. And, of course, kernel uniformity is of real help in getting the best results out of the corn planter.

Obtaining a better variety.—The best varieties are usually those which have been grown so long in a community that they are thoroughly adapted to the soil and climate. However, it often happens that higher yielding sorts can be brought in from outside especially if the soil and climate are similar. If

the soil and climate are different it may take several years to acclimate the newly introduced sort to the point where it will yield as much as the home varieties.

THE ADAPTATION OF CORN

Length of season.—Corn must be well adapted to the probable length of season if it is to yield well. Under long season conditions, the corn plants which seem to yield best are rather tall and leafy and the kernels tend to be either large or deep. At the Nebraska station, in the same field side by side, a strain of Reid Yellow Dent which had been developed in southern Nebraska was grown in comparison with another strain of Reid which had been developed one hundred miles farther north, in north-central Nebraska. The plants of the northern Reid were 1 foot shorter; the ears were nearly an inch shorter, and the ear circumference was one-third of an inch less. The kernels of the northern corn, even when grown under the same conditions as the southern corn, were slightly more shallow and the shelling percentage was 82 per cent for the northern corn and 85 per cent for the southern. The smaller stalk and ear made it possible for the northern Reid to ripen a week or ten days earlier than the southern Reid.

In the latitude of Iowa and the states to the north of Iowa there is always risk when seed corn is moved north or south by one hundred miles or more. It should be said, however, that when Krug corn was brought from Woodford county, Illinois, one hundred miles north to Story county, Iowa, the yield the first year was very good, much better, in fact, than the majority of the Story county varieties when grown side by side on the same farms. It happens, however, that both so far as summer temperatures and length of corn-growing season are concerned, Woodford county, Illinois, is almost identical with Story county, Iowa. It would seem to be quite safe to move a high-yielding strain one hundred miles north or south, provided that the climatic conditions are nearly the same. Corn from central

Illinois has nearly always done well in central Iowa, even though central Iowa is one hundred miles farther north. But when corn in central Illinois is moved one hundred miles north into northern Illinois, where the summer temperatures average two or three degrees lower and the season is a week or two shorter, the result is oftentimes soft corn. Moving northern corn south one hundred miles may not cause quite as serious trouble as moving southern corn north, but as a rule the yield is 15 or 20 per cent less than would have been obtained with a variety of corn which had become accustomed to utilizing the slightly longer season.

Effect of soil differences.—Farmers know that there are some varieties which yield splendidly on a certain farm, but yield poorly on another soil type only fifteen or twenty miles away. They know that on rich land Reid Yellow Dent is one of the best varieties in the central part of the Corn Belt, but on poor land many of them favor white varieties, especially Silver Mine.

Experimental work by Hoffer, at the Indiana station, indicates that some strains of corn are much more likely than others to absorb harmful aluminum and iron from the soil when they should be absorbing phosphorus and potash. It seems that on rich soil certain strains of corn are not at all susceptible to iron and aluminum injury, whereas on poor soils they are decidedly susceptible. The work at the Indiana station may eventually provide a scientific explanation of the practical fact recognized by farmers that some varieties are adapted to poor land and some to rich land. When this explanation finally is available, it may be possible to breed corn more definitely for poor and rich land conditions than is possible to-day.

Effect of moisture and leaf size.—It seems that corn plants with broad, long leaves tend to give a slightly higher yield, other things being equal, when there is plenty of moisture. In dry seasons, however, the advantage is with the narrow-leafed plants. East of the Missouri River the balance between wet and dry seasons is such that it does not seem to make much

difference whether broad- or narrow-leafed plants are favored. It is in such states as Nebraska and Kansas that the moisture situation is really acute.

At the Nebraska station, it was found that there is a very definite tendency for the plants with a low leaf area to give a higher yield than those with a high leaf area. The amount of moisture given off by corn plants varies almost directly with the leaf area, and if the moisture is limited, there may be a decided advantage in rather narrow leaves. The low leaf area strains are associated with rather long, slender, smooth ears with shallow grain, whereas the high leaf area strains tend to be associated with rather short, fat ears with deep and somewhat rough kernels. It is possible that this rough type may yield more than the other when plenty of moisture is available; but when the moisture is not available, the experiments indicate that the low leaf area strains have an advantage of 5 or 6 bushels per acre over the high leaf area strains under Nebraska conditions.

There have been a great many experiments at the Nebraska station comparing the yielding power of corn imported from Iowa, Illinois, Indiana, and Ohio with the strains developed locally. Occasionally in a favorable season the imported seed has yielded practically as well as the Nebraska-grown seed, but in the average season, and especially in the dry seasons, the locally grown seed has yielded much better. One year, for example, the corn from Illinois, Indiana, and Ohio averaged 40 bushels per acre under the same conditions as those under which the locally grown varieties developed near the experiment station averaged 49 bushels per acre. Part of this difference in yield may have been due to soil differences or other factors not well understood, but most of it unquestionably was due to the change in the moisture situation.

Effect of length of day.—Long hours of sunlight such as we have in late June and early July in the northern latitudes pro-

mote vegetative vigor in corn. When the day shortens, as it does along in late summer, the plant is encouraged to put out silks and tassels. These light relationships have been proved chiefly by Garner and Allard of the United States Department of Agriculture. As to just what they mean in a practical way, no one knows so very well yet.

Well-acclimated varieties from North Dakota, which grow 6 feet tall under North Dakota conditions, will oftentimes grow only 4 feet tall in Iowa. On the best Iowa soil, with the most careful cultivation, they will oftentimes yield only 20 bushels per acre whereas in North Dakota they yield 40 bushels. Perhaps soil differences have something to do with the situation, but it would seem that most of the variation is due to the difference in length of day during the growing season. Apparently, there are not enough hours of sunlight in Iowa during June and July to encourage the vegetative vigor which is obtained in North Dakota with the longer day.

Southern varieties of corn brought into Iowa will produce a much ranker stalk than they do when grown under their native conditions. Here again it may be that the greater number of hours of daylight in Iowa during June and July cause southern corn to grow more vigorously than the smaller number of hours of daylight in the South. This whole matter of length of day is still largely in the realm of scientific theory.

Resisting cold.—Anyone who will take the trouble to plant a hundred rows of corn, in August, each row from a different ear, will find a very interesting study when frost comes. Some of the rows will resist frost much better than others. If the first frost occurs at a temperature down only to 28°, it will be found that some of the rows will still remain fairly green, while others will be killed entirely. Although no practical work has been done on this problem as yet, it is certain that there is a great difference between different strains of corn in their ability to resist cold. Holbert, of the United States Department of Agriculture, has found that some strains of corn are subject

to chilling even at 46°and will die as a result, while other strains will live even at 26°.

At the Wisconsin station, germinating ears of corn in an ice-box germinator has been tested and results show that some strains germinate even though the temperature is kept continuously down around 45°.

The work by Holbert, of the United States Department of Agriculture, indicates that cold resistance in corn is due to the presence of a certain chemical substance. Apparently, the day will come when strains of corn will be available which can be planted much earlier in the spring than types now used and which will also stand a light frost in the fall.

No one knows to-day to what extent the northern varieties are adapted to their northern conditions, because of smaller plant and ear, and to what extent they are adapted because they resist cold better.

Heat-resisting.—Some strains of corn undoubtedly resist high temperatures better than others. Whenever the temperature goes above 100°, corn is nearly always damaged. This is partly because such a high temperature evaporates water from the leaves more rapidly than it can be pumped from the soil. Also such temperatures nearly aways come at the time when the pollen is flying, and an hour or so of such a high temperature seems to kill the pollen. Presumably, a variety which produces an unusually large amount of pollen would be to some extent heat resistant. No genuine scientific study, however, has been given to this problem of heat resistance as distinguished from drouth resistance.

Insect-resisting.—Certain strains of corn seem to resist insect attacks better than others. For example, in Illinois the Democrat or Champion White Pearl variety, which is a rather flinty white sort, resists chinch bugs much better than Reid Yellow Dent. Where there is no chinch bug infestation, the Reid Yellow Dent may yield 3 or 4 bushels more per acre than the Democrat corn, but where there is serious damage by

chinch bugs, the Democrat corn may yield 10 or 12 bushels more per acre than the Reid Yellow Dent.

In the South, it is important, in selecting seed corn, to choose ears with the husk fitting tightly and coming out for some distance past the tip. Husks of this sort help the corn to resist damage by the corn-ear worm and the weevil.

It may be that certain strains of corn resist the corn-root louse better than others. This has not been demonstrated as yet, either practically or scientifically, but Gernert, formerly of the Illinois station, found a number of years ago that teosinte, a close relative of corn, was not infested with the corn-root louse on the same land where corn was seriously infested. Moreover, when he crossed teosinte with corn he found that the hybrid was free from damage by the corn-root louse. This would suggest that in all probability certain strains of corn are resistant to corn-root louse damage.

No careful work has been done as yet on developing strains of corn resistant to the European corn borer. Preliminary observations indicate that the dent varieties are more resistant than flint to European corn-borer damage because of the fact that their stalks are larger and the plants grow more vigorously. As the European corn borer becomes more widely spread in the United States, there will doubtless be a great opportunity for fundamental scientific work in developing sorts which will resist European corn-borer damage most effectively.

Buying unadapted seed corn.—Any farmer who buys seed corn, unless he buys it direct from the grower or from a seedsman who guarantees the origin, is running a great risk. The greatest risk is that he will be buying seed which was grown more than a hundred miles north or south of his farm. Another risk is that the seed may be of low germinating power.

Men on the edge of the Corn Belt are especially likely to make the mistake of buying seed corn which is not adapted to their situation. Because of unfavorable soil and climatic conditions, they may be getting yields of less than 30 bushels per

acre, and therefore may think that their seed corn is running out because it doesn't look so very well. Hundreds of these men have made the mistake of buying fine-looking seed corn from the Corn Belt, only to find that when grown under their situation it would not yield as well as their native seed.

Using home-grown seed corn.—By all means rely on home-grown seed until a test on the home farm has definitely proved it to be inferior. The corn as grown by the average Corn-Belt farmer on his home farm will outyield the ordinary seed corn which he can buy by at least 5 bushels per acre. But at the same time it must be recognized that there are thousands of farmers who can find a more productive strain than they now have. It is worth while, therefore, to be always trying a peck or even a bushel of purchased seed corn and comparing it in yielding power with the home variety. In buying this seed corn for trial, however, use judgment. Buy it from someone whose corn has made a record in yielding power. Buy it from someone whose soil and climatic conditions are similar to yours. If you have to, you can afford to pay five or even ten dollars a bushel. Remember that a bushel of seed corn plants seven or eight acres and will produce on the average about three hundred bushels. A bushel of corn not adapted to your situation may easily cause you a loss of twenty or thirty dollars, whereas a bushel of really good seed corn, which is definitely better than your home variety, may give you a profit of forty or fifty dollars.

SELECTED LIST OF REFERENCES

Hughes, H. D. The Germination Test of Seed Corn. Iowa Bul. 135. 1913.

Williams, C. G., and Welton, F. A. Corn Experiments. Ohio Bul. 282. 1915.

Kiesselbach, T. A. Corn Investigations. Nebr. Res. Bul. 20. 1922.

Holbert, J. R., Burlison, W. L., Koehler, B., Woodworth, C. M., and Dungan, G. H. Corn Root, Stalk, and Ear Rot Diseases and Their Control Through Seed Selection and Breeding. Ill. Bul. 255. 1924.

Hume, A. N., and Franzke, C. J. The Germination of Seed Corn and Its Relation to the Occurrence of Molds During Germination. So. Dak. Bul. 275. 1933.

CHAPTER V

CORN SOILS AND PREPARATION OF SEED BED

THE best corn soils are well-drained, deep, dark loams. Sandy soils, unless heavily manured, are not desirable for corn, as they dry out quickly and are usually low in fertility. On the other hand, clay soils are, as a rule, poorly drained and too compact to produce the best corn.

The good corn soils of central Illinois and northern Iowa contain in the plowed soil of an acre about 1200 pounds of phosphorus, 4500 pounds of nitrogen, and 35,000 pounds of potassium. On this type of soil, 1 or 2 per cent of the nitrogen and ½ to 1 per cent of the phosphorus seem to become available in the ordinary year. A 40-bushel corn crop (grain and stover) removes from the soil 60 pounds of nitrogen, 8 pounds of phosphorus and 28 pounds of potassium. Nitrogen and phosphorus are the two elements that are likely to limit corn yield. On deep peats, however, and in the eastern and southern parts of the Corn Belt, potassium is often lacking. Calcium, applied in the form of lime, often gives an increase of 3 to 4 bushels of corn per acre in the Corn Belt east of the Missouri River.

Corn is the rankest feeding and the most destructive of soil fertility of all our common crops. Only on the very richest soils can corn be grown for more than two years in succession with any assurance of profit. In humid regions, corn yields may be maintained or increased by the use of: (1) rotations, (2) barnyard manure, (3) clover, (4) crop residues, (5) good tillage, (6) commercial fertilizers.

Crop rotations.—The all-important and economical way of maintaining corn yields is to use proper crop rotations. Of

course, the short-time tenant can not make very much use of the rotation. In other cases, rotation is very valuable, and should be an important part of the fertility plan of a farm. The most common rotations in the Corn Belt (in some sections wheat is grown instead of oats) are:

1. Continuous corn.
2. Corn-oats.
3. Corn-oats-clover.
4. Corn-corn-oats-clover.

When corn is grown on good land continuously, the available fertility not only decreases rapidly, but there tends to be increasing damage from corn insects and diseases. After ten or fifteen years of continuous corn growing, the yield tends to be about 25 bushels per acre, as contrasted with 35 bushels where the corn and oats are rotated, and 65 bushels where there is a rotation of corn, corn, oats and clover, and where eight tons of manure are applied once every four years.

The corn, oats, clover rotation is preferred to the corn, corn, oats, clover rotation on the poorer soils and will give an increase of about 5 bushels of corn to the acre.

The typical, good corn soil of Iowa and central Illinois yields about 55 bushels of corn, one year with another, when a rotation of corn, corn, oats and clover is used and when eight tons of manure are applied per acre every eight or nine years. If no manure whatever is used, and reliance is placed solely on a rotation of corn, corn, oats and clover for maintaining yields, the average acre corn yield one year with another on typical good corn soil should be around 45 bushels, with the tendency very slightly downward as the lime leaches out of the soil and it becomes more difficult to get a stand of clover every four years. If a rotation of corn and oats alone is used without any clover, the yield should be around 35 bushels per acre, but with the tendency gradually downward. For ten or fifteen years there may be an average of only 5 or 6 bushels difference between the acre yield of a corn and oats rotation and that of a corn, corn, oats and clover rotation, but as the years go on, the difference seems to widen out to about 15 bushels per acre.

Barnyard manure.—If the labor spent on the corn crop is to bring in more than hired-hand wages, the yield should be more than 40 bushels per acre. But just what is the most practical plan of building up a corn soil beyond this point depends on the particular situation of each farmer. The man who has possession of a farm for only two or three years may find it decidedly inadvisable to make any effort to grow clover. But no matter how a man is situated, it almost invariably pays to haul out all

FIG. 23.—Spreading manure is one of the most important jobs connected with corn growing.

manure every spring and every fall (oftener if it is at all convenient) and spread it at the rate of about eight tons per acre on land which is to be plowed for corn. If only enough manure were available, the problem of maintaining a highly productive corn soil would be very simple. Unfortunately, on most Corn Belt farms, there is available enough manure to give an application of eight tons per acre only once in every eight years. Under practical conditions, the fields near the barn get eight tons per acre once every four years, and the outlying fields get manure rarely if ever.

A ton of manure contains about 10 pounds of nitrogen, 2 pounds of phosphorus and 10 pounds of potassium, and it normally has the ability of eventually increasing the corn yield by about 3 bushels, as well as having some effect on the small grain and clover. The first step in building up a corn soil is to haul out the manure. The man who does not do that is rarely justified in spending money for lime, phosphate or other fertilizer.

Clover.—Where a man has possession of a farm for a number of years, the third step in building up a highly productive corn soil is to grow clover once in every four years, instead of only once in every fifteen or twenty years, as is the case on most Corn Belt farms. But in order to grow clover successfully, it is necessary in many sections to apply 2 tons of limestone and 200 pounds of super phosphate (or 1000 pounds of rock phosphate) per acre once every four years. The limestone is best applied just previous to clover seeding, but the super phosphate or rock phosphate is best mixed with the manure as it is loaded just previous to being hauled out to the corn ground.

Plow under cornstalks.[1] — "Cornstalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as 4 tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil."

Proper handling.[2]—" It is a common practice in the Corn Belt to pasture the cornstalks during the winter, and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be

[1] Illinois Soil Report No. 24.
[2] Illinois Soil Report No. 24.

cloddy as a result. If tramped too long in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling, which is unfavorable to physical, chemical and biological processes. The bad effect will be greater if cropping has reduced the organic matter below the amount necessary to maintain good tilth."

Commercial fertilizers.—Having made the best utilization possible of rotations, manure, legumes and crop residues, the question arises whether mineral plant foods can be used profitably. It is well known that even livestock farming, with the most careful conservation of manure, does not maintain fertility (unless concentrates bought from outside the farm are fed). One of the most effective methods of increasing the value of manure is reinforcement with phosphorus. The use of 320 pounds of super phosphate with 8 tons of manure, at the Ohio experiment station, has increased the yields of corn 6.2 bushels; of wheat, 3.3 bushels, and of clover hay, 413 pounds.

The effects of fertilizer are not always confined to an increase in yield. Quality, maturity and composition are other important effects, concerning which, however, little is known under Corn Belt conditions. The physiological effects of small amounts of plant food, applied at various times in the growth of the plant, have yet to be studied. The effects of nitrogen, phosphorus and potassium are not so simple as are commonly supposed. At the Wisconsin station, small amounts of fertilizers applied in the hill for corn have given better results than larger amounts broadcast. The use of fertilizer in the hill is also thought to increase the salt concentration of the corn sap sufficiently to enable it to withstand a lower temperature than unfertilized corn. One hundred pounds of super phosphate per

acre in the hill at time of planting the corn has given good results in Missouri.

On peat soils 50 to 100 pounds per acre of muriate of potash may make the entire difference between success and failure of the corn crop. On most other soils potash rarely pays with corn.

Such nitrogenous fertilizers as nitrate of soda, dried blood, etc., increase corn yields but usually cost more than the value of the increase. Clover grown in the rotation will ordinarily furnish the necessary nitrogen for corn at less than one-fifth the cost of nitrogen in nitrate of soda.

Complete commercial fertilizers, such as the 2-12-2 (2 per cent nitrogen, 12 per cent phosphoric acid, and 2 per cent potash) ordinarily do not give much better results with corn than superphosphate. In a large number of Iowa experiments, 270 pounds of such a fertilizer was much more expensive and no more valuable than 200 pounds of super phosphate. Generally speaking, super phosphate, at the rate of 150 to 200 pounds per acre, is the best commercial fertilizer with which to experiment.

Preparation of the Seed Bed

In preparing land for corn planting, the big objects are to make it easy to kill weeds and to make it possible to plant the corn at a uniform depth. Ideally, the seed-bed should be firm with a mellow, level surface and with the trash cut up finely and well covered. Several diskings and harrowings after plowing kill many weeds when young which otherwise would have to be killed after the corn is up, with the corn cultivator.

Corn is planted on ground which has been in corn, small grain or sod the previous year. In the Corn Belt, about 35 per cent of the corn is planted on cornstalk ground, 45 per cent on small grain stubble and 20 per cent on sod ground. Inasmuch as the methods of seed-bed preparation vary slightly, a a separate description is given for each of the three.

Preparing cornstalk ground.—The first thing is to break the stalks. Many farmers break the stalks with a railroad iron or

heavy plank or harrow and then rake and burn. Most of the best farmers, who value the future fertility of their soil, do not burn their stalks unless they are so very heavy as to interfere seriously in planting and cultivation. Farmers who do not burn their stalks, generally knock them down and cut them up at the same time by disking. Only rarely is a stalk cutter used, and in such a case stalk cutting is usually followed by disking.

Plowing is best done in early April, soon after the stalks have been put in shape so that they can be turned under easily.

FIG. 24.—Disking the cornstalks.

The most practical depth is about 5 inches. At the Illinois station, as a four-year average with corn following corn, it was found that 7-inch spring plowing yielded 62.3 bushels and 3.5-inch spring plowing 60.9 bushels. A difference of only 1.4 bushels per acre is scarcely enough to pay for plowing twice as deep. The practical conclusion of this experiment, as well as the belief of experienced farmers, is that 5-inch plowing is as good as any when corn follows corn.

Fall plowing of cornstalk land is possible only in case husking has been done unusually early or the corn has been cut for fodder

or silage. At the Illinois station, it was found as a four-year average with corn following corn that land fall-plowed 7 inches deep yielded 63.3 bushels, whereas land spring-plowed yielded 62.3 bushels. In the same experiment, land fall-plowed 13 inches deep yielded 63.6 bushels. Evidently the time and depth of plowing cornstalk land does not have any great influence on yield. The farmer who spring-plows cornstalk land 5 inches deep is evidently following sound practice.

In the case of spring plowing, each half day's plowing should be harrowed in the direction of plowing, with a spike-tooth harrow, (1) to prevent the formation of clods and loss of moisture by evaporation, and (2) to level the surface and make disking easier.

A week or so before planting, one or two diskings should be given the plowed ground. Disking at this time will kill a great many weeds which are just beginning to sprout, and will compact the lower part of the seed-bed while at the same time the upper part of the seed-bed is made loose and mellow. If only one disking and one harrowing are given just before planting, it is best to have the disking go crosswise of the plowing, and the harrowing crosswise of the disking. The final result of the disking and harrowing should be a seed-bed in which the corn can be planted in moist ground at a uniform depth of about 2 inches.

Plowing to fight European corn borer.—Experiments prove that one of the most practical ways to fight the European corn borer is to turn under all cornstalks completely. This can be done if the plow is equipped with a running coulter and jointer and three wires attached to the axle. The depth of plowing need not be more than 6 inches. The borers can find their way to the surface but they perish if there is no vegetation or rubbish on the surface.

Preparing small-grain stubble.—Small-grain stubble which is to be put into corn is best plowed in the fall, so as to make the spring work less rushing. Theoretically, fall plowing has many other advantages, such as destruction of insects and more

complete decay of the stubble and weeds turned under. Freezing and thawing during the winter mellow the exposed soil so that it takes but little labor to put it into perfect condition for corn planting. Fall plowing should not be used with land which

FIG. 25.—Good plowing.

either washes or blows badly. Practical farmers fall-plow stubble land about 6 inches deep, and there are no experiments indicating that this is not about right.

When small grain stubble is plowed in the spring, 5 inches

seems ordinarily to be the most practical depth. Following plowing, spring-plowed small-grain stubble land is harrowed, disked and harrowed in the same way as cornstalk land. A cultipacker or roller is often used to very good advantage just previous to or just following corn planting in the case of land which was in small grain the year before.

Preparing sod ground.—There are more advantages in plowing clover, timothy or blue-grass sod for corn in the fall than stubble ground. Sweet-clover sod after one year's growth is an

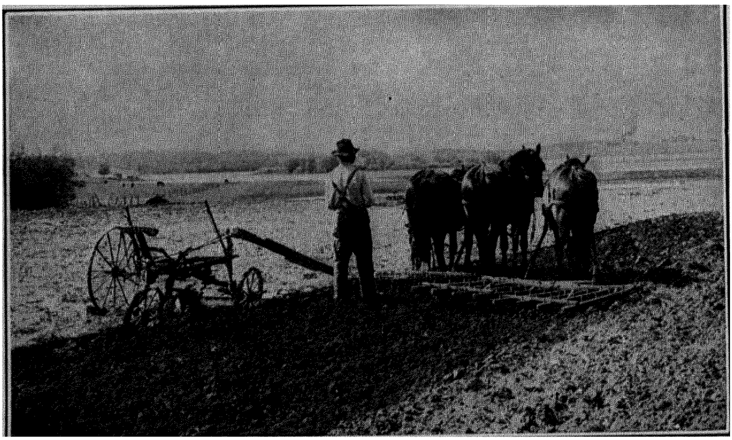


FIG. 26.—Harrow each half-day's plowing.

exception. It should be spring-plowed in order to keep down volunteer growth. It is advisable to plow other sods late in the fall to allow for a maximum growth of pasture or green manure. Fall-plowed sod is far easier to work than spring-plowed sod. Fall plowing of sod reduces the damage done to corn by drouth the following season. In addition, late fall plowing will destroy many cut-worms, wire-worms and other insects which are more noticeable after sod. Blue-grass sod should be plowed shallow, and clover sod deep, because of the difference in rate of decay. It is best to allow the fall-plowed ground to lie rough over the

winter, but it must be worked down early in the spring and otherwise carefully managed. If spring-plowed, sod ground should be disked first, plowed early and shallow, and then disked and harrowed thoroughly. After spring plowing of sod ground, double disking with cross disking is necessary. The amount of work required to put the ground in good shape for corn will depend on the condition of the sod and the time of breaking.

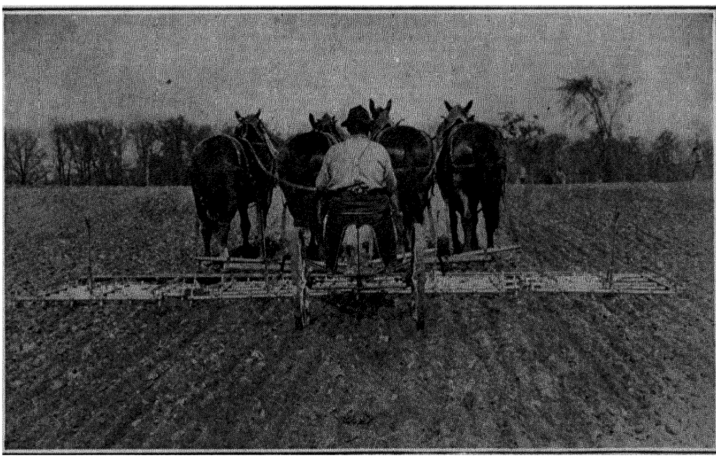


FIG. 27.—Harrowing 40 acres of corn land in a day.

Wild grass sod is harder to work than clover and timothy sod, and is much slower to decay. This kind of sod should be plowed in the early summer, if possible. Deep breaking, 4 to 6 inches, should be done, and the furrow slice should be turned over flat. Shallow plowing, 2 to 4 inches, followed by "back-setting" (second plowing) about 2 inches deeper, after the sod has rotted, is a desirable method for tough sod. In either case, the ground should be thoroughly packed and disked to put the seed bed in good condition for corn.

At the Illinois station, as a six-year average in plowing sweet clover at the end of its second year of growth, it was found that

13-inch fall plowing gave a yield of 65.7 bushels; 7-inch fall plowing, 65.0 bushels; 7-inch spring plowing, 65.9 bushels, and 3.5-inch spring plowing, 63.6 bushels. This six-year experiment would indicate that with leguminous sods fall plowing may not have quite as great an advantage as theoretical considerations would indicate.

Standard day's work.—The amount of work done in a ten-hour day on average Corn Belt farms (based on 1922 Yearbook, United States Department of Agriculture) is as follows:

	Acres
Plowing with horses:	
Walking, 14-inch, one man, two horses	1.9
Sulky, 14-inch, one man, four horses	2.6
Gang, 24-inch, one man, four horses	4.1
Gang, 24-inch, one man, six horses	4.9
Plowing with tractor:	
Two-plow	6.7
Three-plow	8.2
Four-plow	10.4
Harrowing with horses:	
Sixteen-foot spike-tooth, one man, four horses	38.7
Disking with horses:	
Eight-foot single disk, well-packed land, one man, four horses	17.1
Eight-foot single disk, freshly plowed land, one man, four horses	15.2

SELECTED LIST OF REFERENCES

MOSIER, J. G., and GUSTAFSON, A. F. Soil Moisture and Tillage for Corn. Ill. Bul. 181. 1915.

WILLIAMS, C. G., and WELTON, F. A. Corn Experiments. Ohio Bul. 282. 1915.

HELM, C. A. Corn in Missouri. Mo. Bul. 185. 1921.

KIESSELBACH, T. A., ANDERSON, A., and LYNESS, W. E. Tillage Practices in Relation to Corn Production. Nebr. Bul. 232. 1928.

MOOERS, C. A. Fertilizers and Manure for Corn. Tenn. Bul. 149. 1933.

SINGLETON, H. P. The Production and Utilization of Corn Grown Under Irrigation in Washington. Wash. Bul. 278. 1933.

CHAPTER VI

PLANTING CORN

THE three common methods of planting corn are: (1) surface planting, (2) listing, and (3) furrow opening. From the information in the following paragraphs the grower should select the method that he should use. In general, surface planting is used over the greater part of the Corn Belt and because of the weed situation, most surface planted corn is checked or planted in hills so as to permit cross-cultivation. Listing is done in dry, windy regions and on light soils. Furrow opening is a modified type of listing.

CORN PLANTERS

Types of check row planters.—Three common types of check row corn planters, on the basis of the planter plate used, are: (1) edge-drop cumulative, (2) flat-drop cumulative, and (3) full-hill drop. The edge drop seems to be the least foolproof of any, but farmers who take great pride in carefully grading seed corn of the Reid Yellow Dent type, often think that they can get more accurate results with an edge-drop planter than with any other sort. Actual experiments indicate, however, that there is no great difference between the edge drop and flat drop and that with rather thick, shallow kernels the flat drop may have a considerable advantage over the edge drop. In tests run by C. L. Reed, of the University of Illinois, it was found that with graded Reid Yellow Dent seed corn, the flat-drop planter gave 88 hills out of 100 with three kernels, whereas the edge drop, with the same seed, had 86 hills, and the

hill drop, 67. With graded corn of the Champion White Pearl, with its thick, shallow kernels, the percentage of accuracy in the case of the flat drop was 86, and the edge drop 69. With both the edge drop and the flat drop, it is especially important to have the right size of planter plate. In this Illinois experiment, for example, the same seed which was planted with 88

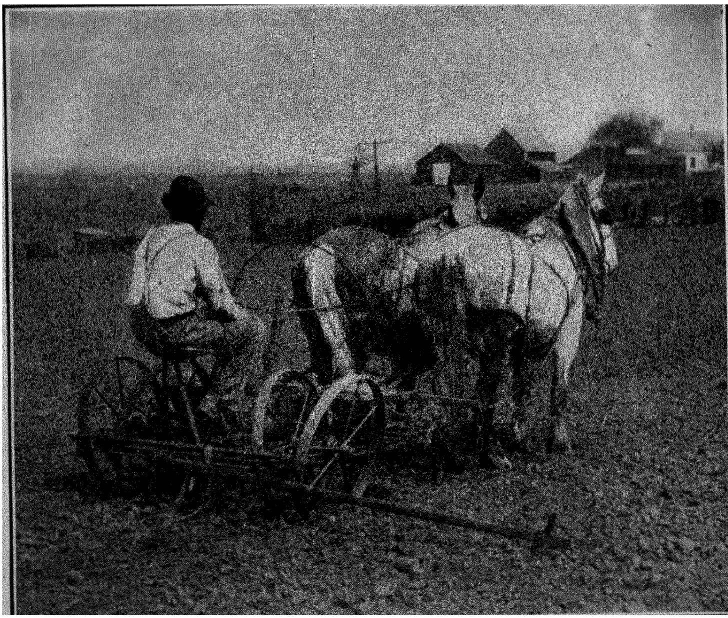


FIG. 28.—Planting corn.

per cent accuracy with the best-adapted flat-drop plate, was planted with only 21 per cent accuracy with the next size smaller flat-drop plate, and in the case of this small plate, over 37 per cent of the hills were twos, 29 per cent ones, and 9 per cent blanks. Moreover, 8 per cent of the hills contained broken kernels when the small plate was used, while when the right size of plate was used, only one hill out of every 200 con-

tained a broken kernel. Apparently, a plate too large does not cause quite so much damage as a plate too small, for in this Illinois experiment, this same graded Reid corn when run through a flat-drop plate one size too large, was all right except that 11 per cent of the hills were fours, as compared with only 3 per cent with the right size of plate. Moreover, there were broken kernels in 3 per cent of the hills, or about six times as many broken kernels as with the right size of plate.

The hill-drop type of planter seems to be decidedly more fool-proof than either the edge cumulative or flat cumulative. Just as good yields can be obtained with the hill drop and more than 70 per cent of the farmers use the hill drop. It seems that the typical hill-drop planter will plant about 70 per cent threes, 20 per cent fours, 3 per cent fives, and 7 per cent twos. Theoretically, the accuracy is less than with either the edge-drop or flat-drop cumulative, but from a yield standpoint there is no difference in the final results obtained. At the Nebraska station, as a five-year average, it was found that alternating hills of one, two, three, four and five plants yielded at the rate of 58.6 bushels per acre, as compared with 59 bushels where every hill contained three plants. It would seem, therefore, that the so-called inaccuracy of the hill-drop planter would have no effect on yields. The hill-drop planter will handle ungraded or odd-shaped corn more accurately than either of the other types.

Calibrating the planter.—With any planter, and especially with the edge- and flat-drop cumulatives, it is important to get the right size of planter plate. This testing, or calibrating, is best done by cleaning off a space on the barn floor and blocking up the planter so that one wheel is free to turn and both wheels are level and the furrow openers have the same position as when planting. There should be room so that the hand can be slipped under the furrow opener to catch the corn as it is dropped while the wheel is being turned at about the same rate as though it were traveling about two and one-half miles an hour. It takes two people to do the work right, and one should keep a record of the number of kernels dropped hill by hill for

about 200 drops. If three kernels are desired per hill, the plate should be changed until at least 70 per cent of the hills have three kernels and no more than 3 per cent of the hills have less than three. With a flat-drop or edge-drop cumulative, it is best to keep changing plates until the accuracy of dropping is at least 80 per cent. In some cases it may be necessary to file a plate which is just the least bit too small. As a rule, it is best to have a plate a little large rather than a little small. The planter plate adjusted to each lot of corn should be put with that particular lot in order to avoid any confusion at planting time.

Corn Planting Methods

Method of checking.—Checking corn so that the rows are straight in both directions is a fine art. As a rule, the planter should be driven back and forth the long way of the field, and the work should begin on the straight side. After laying the wire across the field, it should be stretched reasonably tight and fastened to the other iron stake—as one practical farmer puts it, "it should be pulled just tight enough so that there will be about seven buttons between the planter fork and where the wire touches the ground." In order to get even cross-checking, it is especially important that the wire should be pulled to the same degree of tightness at both ends. The wire is then connected with the planter and the first two rows are planted with one trip across the field. At the end of the trip, the wire is released and moved over twice the distance between the rows. In moving the stake with the planter wire attached, it seems to be best to set the stake in the ground about 16 feet back of the planter and in line with the tongue of the planter.

After the first few rounds with the corn planter, it is well to dig up a few hills in different rows to see how they are cross-

checking. If they are considerably out of line, it is because the corn is being dropped ahead of the button or behind the button. This can be corrected by adjusting the hitch. It is always essential of course, to drive the planter as straight as possible if the rows crosswise are to be straight. A steady-moving team is essential, because the speed of the team influences where the corn is being dropped relative to the knots on the wire. A fast-moving planter tends to drop the

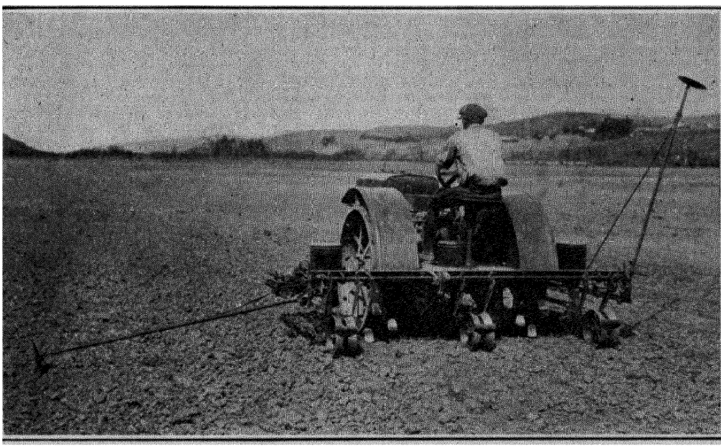


FIG. 29.—Planting three rows of corn with a tractor.

corn ahead of the button, and a slow-moving planter behind the button. If there are surface irregularities, such as ridges or depressions, it is almost impossible to make the cross-checking perfectly straight.

Drilling.—With drilled corn the rows are customarily put about 3½ feet apart, as with checked corn, but in the rows the kernels are customarily dropped about one every 12 or 14 inches, instead of three in a hill, 3½ feet apart. The drilled corn can be cultivated only one way, which means that if the ground is at all weedy the corn will suffer more from weed competition. Experiments indicate that when the ground is

not weedy and the same number of kernels are planted on an acre as with checked corn, the yield is fully as great as with checked corn. Ordinarily, however, the weed situation is such as to give checked corn a slight advantage over drilled corn. The ordinary corn planter can be used satisfactorily for drilling. In the northwest, grain drills with part of the holes stopped up have also been used for drilling.

Drilled corn cuts a little more easily with a corn binder than checked corn, and for that reason, when the ground is clean, both fodder corn and silage corn are often drilled. Drilling is also used occasionally on hillsides to check erosion, the drills being at right angles to the slope of the hill.

Listing

Listing is practiced in western Kansas, western Nebraska, Oklahoma and parts of northwestern Missouri and western Iowa. Listing is based on the idea that if corn is planted in a furrow and then earth is filled in as the corn plants grow, a large root system will be encouraged because roots will be put out from the lower joints of the corn plants which are covered. Ordinary deep planting will not accomplish this purpose, but planting in a furrow followed by filling in the furrow with earth will result in an unusually large root system. When corn is planted in the bottom of a furrow, however, it does not grow quite as vigorously early in the spring because the soil is cold, and if the weather is wet there is an additional handicap. The stalks of listed corn are generally slightly smaller than the stalks of surface-planted corn of the same variety, planted under the same soil and climatic conditions. It seems that planting corn in the bottom of a furrow with a lister will continue to be popular only in seasons which are rather dry. Listing seems never to be practiced on shallow or poorly drained soil. The farmers of western Kansas and Nebraska think that listed corn stands drouth better and does not blow down so easily as

surface-planted corn. The biggest argument for listed corn, however, is that listing is cheaper and quicker than surface planting.

Listing is the process of throwing open a series of furrows across a field by means of a double moldboard plow that throws the soil both ways. In connection with this double plow is a drill attachment by means of which the corn is planted in the bottom of the furrow.

Ordinarily, Kansas and Nebraska farmers single list their corn, which means that the ground between the rows is not

FIG. 30.—The two-row lister in action.

plowed, although there is a covering of loose earth over it which is thrown out by the lister in making furrows every 3½ feet. With single listing, considerable labor in the way of plowing, harrowing, disking, etc., is avoided, with the result that the typical acre of western Kansas or Nebraska corn requires about three hours less man labor and ten hours less horse labor than the typical acre of Iowa or central Illinois corn.

With double listing the corn is not planted at the time of the first listing—but at the time of the second listing, which is

done in between the rows of the first listing, the corn is planted. This method results in breaking up the ground much more thoroughly than single listing, but experiments do not prove that it has any particular advantage from the standpoint of yield over single listing.

Furrow opening.—A furrow opener consists of a pair of disks or shovels attached to the planter runner slightly in front of where the seed is dropped. These disks may be set at different depths, but ordinarily they throw out 3 or 4 inches of dirt and the corn is planted in the moist dirt at the bottom of this little furrow. After the corn is up, the cultivation or harrowing that is done in filling up this little furrow makes it possible oftentimes to kill weeds close around the corn more effectively than would otherwise be the case. Furrow opening seems to be the most popular in the western part of the Corn Belt in sections where listed corn does well, but where, for some reason, it is desirable to check instead of list. It will be noted from the following table that as an average of nine years, in northwestern Missouri, corn planted with furrow openers yielded about 7 bushels more per acre than corn planted in the ordinary way, although it yielded about 5 bushels per acre less than corn planted with the lister. Furrow opening attachments for any corn planter can be bought for a few dollars, but in the central part of the Corn Belt they are used very little.

In Table XI it will be noted that in northwestern Missouri single listed corn yielded better than ordinary surface-planted corn in every one of the nine years under experiment. In warm, dry soils in warm dry seasons, listed corn has apparently had an advantage over surface-planted corn. The most practical kind of listing, from the standpoint of yield and labor-saving, is listing without disking.

Farther north and east in the Corn Belt where the soil is not so warm and dry as it is in northwestern Missouri, Kansas,

and Nebraska, the practice of listing is not so practicable. There is some reason to believe, however, that listing should be used somewhat more extensively in the eastern part of the Corn Belt than it has been hitherto.

TABLE XI

YIELD OF CORN AS DETERMINED BY THE METHOD OF PREPARING THE SEED BED (MARYVILLE, NODAWAY COUNTY, MISSOURI)—1911 TO 1920

Method of Preparing Seed Bed	Yield in Bushels per Acre									Nine-year aver., bushels per acre	Av. increase over surface planting
	1911	1912	1913	1914	1915	1916	1917	1919	1920		
Ground plowed, crop surface planted.	49.9	62.8	14.5	44.9	41.1	46 3	75.0	78.5	51.7	51.6	
Ground plowed, crop planted in shallow furrows.	55.6	76.5	18.6	51.4	53.0	60.9	81 9	78.4	55.2	59.0	7.4
Double listed . . .	56.9	73.0	18.2	54.6	44 3	53.8	68.4	84 4	54.7	57.6	6.0
Double disked, single listed. . . .	67.4	75.5	36.7	54.1	42.5	56 7	80.2	75.2	53.2	60.2	8.6
No disking, single listed.	60 3	80.0	43.1	58.1	45 2	59 2	84.2	91.9	55.9	64.2	12.6
Average.	58.0	73.5	28.2	52 6	45.2	55 3	77 9	81.7	54.1	58.5	
Inches of rainfall, June, July and August.	5.71	6.30	8.78	6.28	31.1	10.8	10.7	8.78	5.28		

Rate of planting.—Thickness of planting depends on variety, soil, latitude, and purpose for which grown. Also it should be kept in mind that in the central part of the Corn Belt only 70 per cent of the kernels planted produce stalks. Most growers in the Corn Belt plan to get about three kernels in a hill, the rows being 3½ feet apart both ways. This distance between rows is more or less standard for planters, check wires and cul-

tivators. In drilled corn the distance between rows is the same as in checked corn, and the kernels should be dropped on the average from 10 to 14 inches apart in the row.

The most careful work on rate of planting corn in the Corn Belt has been done by the Ohio experiment station. The climate under which these Ohio experiments were conducted is quite typical of the north-central part of the Corn Belt, but the soil is decidedly better than average. The results of these Ohio experiments are shown in tabulated form.

In these Ohio experiments it is important to remember that all the corn was planted thick and then thinned down to the required number of stalks per hill. So far as the practical farmer is concerned, it is necessary to plant about four kernels per hill in order to get three stalks per hill. Apparently, on 60-bushel corn land in the northern part of the Corn Belt, it pays to plant about four kernels per hill with the idea of getting three stalks per hill. Even thicker planting may give a slightly greater yield, but with the thicker planting the greater yield is composed almost exclusively of nubbins. Next to the last of these tables reveals the fact that when there are four stalks to the hill there are three times as many plants per acre bearing nubbins as when there are two stalks per hill, and about four times as many barren plants per acre as when there are two stalks to the hill. Thick planting on rich land will increase the yield if the season is favorable, but it may reduce the average size of ear to a point where there is considerable extra labor in husking. Of course, this extra labor of husking is not a factor when the corn is planted for silage, and it would seem that, except on poor land, it would be worth while to plant silage corn at the rate of about five kernels per hill or else drop the kernels 8 inches apart in drilled rows.

Over the southern half of the Corn Belt, with the larger-stalked varieties of corn and on soil which is of average or below average fertility, it seems that practical farmers favor what is known as the two and three rate of planting. Thicker

TABLE XII

Relation of Yield to Rate of Planting—Ohio Tests

Bushels of Shelled Corn per Acre—Ears and Nubbins

Stalks per hill	1	2	3	4	5
Four years of lowest yield—1910, 1907, 1923, 1912	25.35	40.31	45.77	44 23	41.22
Four years of highest yield—1905, 1909, 1917, 1921	37.67	63 35	79.24	85.68	89.93
Twenty-one year average, 1904–24	39.91	51.26	62.92	66 64	65.79

Bushels of Shelled Corn per Acre—Nubbins Only

Four years of lowest yield—1910, 1907, 1923, 1912	1.85	4 71	8.33	12 99	16.46
Four years of highest yield—1905, 1909, 1917, 1921	2 19	2.05	3.74	7.58	12.46
Twenty-one year average, 1904–24	1.91	3.25	5.66	10.46	15.82

Bushels of Shelled Corn per Acre—Sorted Ears Only

Four years of lowest yield—1910, 1907, 1923, 1912	23.50	35.62	37.44	31 24	24.76
Four years of highest yield—1905, 1909, 1917, 1921	35.48	61.30	75.70	78.10	77.47
Twenty-one year average, 1904–24	30.00	48.01	57.26	56.18	49.97

Barren Plants, Nubbin Plants and Good Plants per Acre

Plants per acre bearing good ears	3,410	5,794	7,663	8,240	7,982
Weight per ear in ounces	11.5	11.0	9.7	8.5	8.0
Plants per acre bearing nubbins	580	976	1,727	3,290	5,158
Weight per ear in ounces	4.25	4.2	4 2	4 2	4.05
Barren plants per acre	302	762	1,615	2,937	4,867
Two-eared plants per acre	737	422	340	247	232

Effect of Rate of Corn Planting on Yield of Stover and Grain per Acre

Pounds of stover per acre	2,114	3,005	3,643	4,030	4,481
Pounds of ear corn per acre	2,260	3,642	4,483	4,776	4,708
Therms of energy in ear corn	1,654	2,659	3,254	3,446	3,398
Therms of energy in stover	668	950	1,152	1,275	1,417
Total therms of energy in grain and stover	2,322	3,609	4,406	4,720	4,815

planting than this on soil of this sort results in a rather high percentage of nubbins, especially if the year is at all dry.

The influence of small-stalked and large-stalked varieties on the most favorable rate of planting is illustrated by a three-year experiment at the Nebraska station. Hogue Yellow Dent, which has a stalk growing about 8 feet tall, was planted at the rate of three, four, and five kernels per hill, and yielded at these rates as a three-year average: 56, 54, and 50 bushels per acre, respectively. Minnesota 23, a small early variety, with stalks growing about 5 feet tall, was planted during the same year at the three, four, and five-kernel rates, and yielded 35, 38, and 42 bushels per acre, respectively. This would seem to indicate that when 90-day corns are planted during June it may be wise to plant five kernels per hill. Also when early corn is planted for hogging down, thick planting may be advisable.

Depth of planting.—Ohio, Indiana, and Illinois experiments indicate that corn planted 1 or 2 inches deep will, on the average, yield at least three or four more bushels per acre than corn planted 3 or 4 inches deep. Shallow planting seems to be especially worth while in rather wet, heavy, cold clay soils. In warm, dry loams it may be worth while occasionally to plant deeper than 2 inches. If the weather has been unusually dry in April and early May, it seems to be a good plan to put the corn down to moist earth even though it is covered with more than 2 inches of soil. In most seasons, the average farmer plants his corn too deep rather than too shallow. Many do this under the mistaken impression that deep-planted corn will have a larger root system. The diagram on page 184 illustrates why this can not be true. No matter how deep corn is planted, it still sends out its permanent root system just underneath the ground. It is only by listing or furrow opening and then filling in the ground around the corn after it has come up, that it is possible to increase the root system. Deep planting has nothing whatever to do with it.

Time of planting.—Corn planting usually begins when the normal mean temperature reaches 55° F., and the bulk of planting is done when the normal mean temperature reaches 61° F., which means about the middle of May in the central part of the Corn Belt. April planting and sometimes early May planting is more difficult to keep clean than later planting, and often the stand is reduced because of cut-worms and other insect damage. About one year in seven or eight a late spring frost will seriously damage corn planted the last week in April. The typical frost kills the upper two or three leaves, but new leaves usually come on after a few days. It is really astonishing what a severe frost corn will stand and yet send up a vigorous new growth from the roots. Farmers have found by experience, however, that if a heavy frost occurs before May 20, it is often best to replant even though the frosted corn will send up a strong new growth. After May 20, it is usually best, unless the frost has been altogether extraordinary, to let the early-planted corn stand.

Experiments in the central part of the Corn Belt indicate that one year with another the highest corn yields are obtained when planting is done the second week in May. Once in a long while there will be a period of cold weather during the first three weeks of May which will result in corn planted late in May yielding more than the early-planted corn. One year with another, however, it seems to pay to plant corn just a little earlier than the average. Many farmers think that corn planted the last two or three days of May or the first two or three days of June yields better than it actually does. In November, at husking time, late-planted corn will usually run around 35 per cent moisture, whereas early-planted corn will contain only about 25 per cent moisture. The ears of the early-planted corn may look considerably smaller, however, than the ears of the late-planted corn, and the yield may seem smaller unless the difference in moisture is taken into account. In soft-corn years, early-planted corn usually has a tremen-

dous advantage. It is in years when the May weather is unusually cold or wet or there is a severe late spring frost, that early-planted corn yields less than late-planted, and in such years it is possible, if the early-planted corn is severely damaged, to replant. As a general rule, it would seem that in the central part of the Corn Belt every effort should be made to plant corn before May 18, and if the weather is unusually favorable, before May 15.

Acres planted per day.—According to the United States Department of Agriculture Year Book for 1922, the standard number of acres planted in a ten-hour day is about as follows:

Two-row planter, 3½-foot rows, one man, two horses .	14.0 acres
By hand, 3½-foot rows, one man	4.5 "

It is estimated that the standard number of acres planted with a lister in a ten-hour day is about as follows:

One man and four horses.	10.0 acres

SELECTED LIST OF REFERENCES

Wiancko, A. T. Corn Improvement. Ind. Bul. 110. 1906.

Chase, L. W., and Chase, C. F. Tests of Corn Planters with Graded Corn. Nebr. Ann. Report 25. 1912.

Robinson, J. L., and Bryan, A. A. Results of 1926 Corn Yield Test. Iowa Corn and Small Grain Growers Assoc. Ames, Iowa. 1927.

Kiesselbach, T. A. Corn Investigations. Nebr. Res. Bul. 20. 1922.

Salter, R. M., Reed, C. O., Barnes, E. E., and Thrash, C. L. Improved Placement of Fertilizers in the Hill for Corn. Ohio Agr. Exp. Sta. Bimonthly Bul. 156. 1932.

Leonard, W. H., and Robertson, D. W. Rate of Planting Corn under Irrigated Conditions. Colo. Bul. 417. 1935.

CHAPTER VII

GROWING CROPS WITH CORN

Occasionally, other crops are grown with corn to balance the corn ration for animals and to utilize the ground better It has not yet been fully proved that the returns warrant either reason for growing some other crop with corn. At any rate, there are many essentials and precautions to keep in mind in order to get the most out of an acre of corn and to feed the corn profitably.

The crops ordinarily planted with corn are soy beans, rape, cowpeas (in the southern Corn Belt), and sometimes pumpkins. Clover and rye have been sown in corn just before the last cultivation of the corn, with varying success. Usually the lack of moisture causes poor results and makes it a poor practice. The crop sown with corn should be well adapted to the locality and add more to the combination than it takes away.

Soy Beans

Soy beans are a comparatively new crop in America, especially in the Corn Belt. Trials during the last twenty years have shown the crop to have a wide range of adaptation, including all the corn and cotton lands of the country. The seeds are four times as rich in protein and fat as shelled corn.

The most popular use of soy beans in the Corn Belt is for planting with corn for hogging-down or for silage. Over 70 per cent of the soy beans grown in the Corn Belt are planted with corn for hogging-down. The beans are planted at the same time as the corn. They are erect-growing annuals which do not interfere with the growth of corn or with cultivation. The

cost of cultivation is not increased by the addition of the beans, and the feeding value of the corn is improved. There is no great difficulty in handling the beans with corn for silage.

FIG. 31.—Soy beans in corn furnish green feed rich in protein.

Effect on yield of corn.—When sown at the ordinary rate of three beans with three kernels of corn per hill, most experiment stations agree that there is some reduction in yield of corn. Practical farmers, however, seem to be of one opinion, that the

total feeding value of the crop is increased. The amount of the decrease in the corn yield will depend almost entirely upon the amount of moisture and plant food available for the crop. If there is sufficient of each for both crops, little decrease in the yield of corn can be noticed, but if the crop is struck by drouth, the corn will suffer before the beans.

On the average in the Corn Belt, it seems that soy beans grown at the rate of two stalks per hill reduce the yield of corn about 6 bushels per acre, and that the yield of beans per acre is about 4 bushels. Of course, there is great variation with the soil and season. As to whether the 4 bushels of soy beans are more than equal in feeding value to the 6 bushels of corn is a debatable question when the corn is hogged down. Table III, giving results of Missouri experiments, indicates that when no tankage is fed, the soy beans are decidedly worth while, but that when tankage is fed, the soy beans are not worth while. When corn and soy beans are used for silage, there is no clear-cut proof as yet that the mixture will produce any more milk or beef per acre than corn silage alone. Theoretically, there should be some advantage, but no careful feeding experiments have yet proved the point.

Method of planting.—The most practical method of planting beans with corn is to place the beans in the hills of corn at the same time the corn is planted. This is best accomplished by means of a bean attachment for the planter, which is operated by the check wire the same as the corn planter. It is also possible to drill corn and drill beans at the same time, or to check corn and drill beans between the hills. The latter method has given greater yields of both corn and beans than hills of corn and beans together, but there are disadvantages in the cultivation of such a planting. Beans and corn may be mixed and planted from the corn planter box, but this is not so satisfactory, as an uneven stand of corn often results because the beans settle to the bottom of the planter box faster than the corn. Practical farmers, by adding a handful or so of beans on top of the corn at each round, can overcome this objection to some extent.

Rate of seeding.—About three beans per hill of corn should be planted. The greater the number of beans per hill, the greater the reduction in the yield of corn.

If three beans are planted per hill, the pounds of beans required for each acre are:

	Pounds Per Acre
Manchu (large seed)	5.0
Medium green (large seed)	5.0
Ito San (medium seed)	3.5
Chestnut (medium seed)	3 5
Ebony (medium seed)	3 5
Midwest (medium to small seed)	3 0
Peking (small seed)	2 0

One bushel of beans, therefore, will plant from twelve to thirty acres, depending on the size of the beans.

Varieties.—The several hundred varieties of soy beans are as different as are varieties of corn, and much of the success in soy bean growing depends upon the choice of the proper variety. To be planted with corn, a variety must be chosen that will ripen with the variety of corn that is used as the companion crop. For silage and sheeping-down, a later variety may be used, but for hogging-down the soy bean variety should be matured when the hogs are turned in. The early varieties, like Ito San and Chestnut, ripen readily in the most northern states. The mid-season kinds, like Peking, Manchu and Medium Green, mature in the Corn Belt. Manchu is a favorite for hogging down.

Inoculation.—Inoculation is an important factor on most Corn Belt soils. The inoculation of the seed or soil is simply applying some substance that is known to carry live bacteria. On fields that have grown a successful crop of soy beans during the past three or four years, the bacteria are usually present in sufficient numbers. On other fields, they should be supplied in order to insure maximum yields. Inoculation, however, is not absolutely necessary for the production of a crop.

There are various methods of inoculation. An easy method

is to use soil from a field that has grown a successful crop of soy beans during the previous year. Dry it in a shady place and when the soil is dry enough to sieve through a piece of screen wire, spread the seed about 2 or 3 inches deep on a clean place. Make a solution of one-half cup of sugar to one quart of hot water for each bushel of beans. When the solution is cool, sprinkle it over the beans to make them sticky. Sift the soil uniformly over the moist beans. After drying a few hours, the beans are ready to plant.

In case no inoculated soil is at hand, commercial cultures may be used with good results. These cultures may be purchased from any seed house. The method of application is essentially the same as the one mentioned, except that hot water must not be used. Directions for the use of commercial cultures always accompany the package and have been found to be reliable. Care should be taken not to wet the beans to such an extent that the seed coats will swell enough to break.

Rape

Rape is closely related to cabbage, turnips and rutabagas. The seed, the root system and the smooth, large, succulent leaves resemble those of cabbage, but there is no tendency to form a head. The plant grows 2 feet tall under average conditions, and on rich, moist soil will grow 3 or more feet in height.

Rape is one of the most valuable pasture crops which can be seeded in the corn at the last cultivation, and is more valuable than soy beans in corn, if a stand can be obtained. However, because of lack of moisture, a stand of rape in corn about twice in every five years is all that may be expected. But since rape seed rarely costs more than 13 cents a pound, and the total cost of seeding will not exceed 75 cents an acre, farmers can afford to seed rape annually with the expectancy of getting stands twice out of five years. The corn and rape growth can be harvested profitably by hogging down or by pasturing with sheep in the fall. The leafy plants also tend to shade the ground suf-

ficiently to keep the land free of weeds. Rape has little effect on the yield of corn in the average year, reducing the corn yield about one-half bushel.

Method of planting.—The seed is generally scattered with a hand seeder at the rate of 3 to 5 pounds per acre, immediately preceding the last cultivation, which should be shallow. It may be sown a little later with a one-horse drill, but the delay in time of seeding and the additional labor are objections which probably more than offset the advantage of providing a more uniform distribution and covering of the seed. The success of late seedings depends largely on the rainfall during July and August.

Some growers are obtaining better results by planting 4 or 5 rape seeds in the corn hill at corn-planting time. This is easily done by mixing the rape and corn seed in the planter box.

Varieties.—There are two types of rape, the winter or biennial and the summer or annual. The biennial kind lives two years where the winters are extremely mild, as in the South and on the Pacific Coast, but in the Corn Belt the plants are killed by hard freezes in late fall, so it is necessary to make new seedings every year. The summer or annual type, which is also known as "bird-seed" rape, produces seed the first season, but the plants do not make sufficient growth to be of value for forage. The winter or biennial kind, usually known as Dwarf Essex rape, is the only one recommended for Corn Belt seeding.

COWPEAS

In the southern Corn Belt and in the South, the cowpeas make a good growth when planted with corn. The crop requires more heat than corn and is not grown to any extent north of the southern line of Iowa Many of the things said about soy beans apply to cowpeas. However, the cowpea is a vining plant and not erect-growing like the soy bean. Cowpeas succeed on poorer soils better than soy beans. They should not be planted until the soil is thoroughly warm. Sim-

ilarly to soy beans, the crop may be sown with corn in one operation with the ordinary corn planter. Broadcast in the corn and covered at the last cultivation, they should be sown about 1 bushel to the acre. If cowpeas have been grown in a locality for a long time, inoculation will not be necessary. The Whippoorwill, New Era, and Iron are common varieties.

PUMPKINS

According to the Iowa experiment station, pumpkins are often used to advantage with corn. The seed is planted in either missing hills or adjacent to every third hill. Corn planters are now available with a pumpkin seed attachment. On a fertile soil the pumpkins do not seriously interfere with the corn crop and are an added source of revenue, yielding from 2 to 3 tons per acre.

Many of the canning factories are ready to contract for this crop in the spring at a specified price, or it may be fed to the stock. Yields ordinarily vary from 2 to 3 tons per acre, depending on the severity of injury from beetles when the plants are small and an adequate moisture supply when the pumpkins are filling out.

OTHER CROPS

Clovers, alfalfa, rye, and many other crops have been sown in corn just before the last cultivation, with varying success. Usually the lack of moisture causes poor results. Although the practice is not widespread or widely recommended, there are occasions when good stands have been obtained and it is very much worth while.

SELECTED LIST OF REFERENCES

ETHERIDGE, W. C., and HELM, C. A. Corn and Soybeans. Mo. Bul. 220. 1924.

SLATE, W. L., and BROWN, B. A. Corn and Soybeans as a Combination Crop for Silage. Conn. Bul. 133. 1925.

MOOERS, C. A. Influence of Cowpea Crop on Yield of Corn. Tenn. Bul. 137. 1927.

HUGHES, H. D. Soybean-Corn Mixtures. Jour. Am. Soc. Agron. Vol. 23. No. 13. P. 1065. 1931.

BORST, H. L., and PARK, J. B. Experiments with Growing Corn and Soybeans in Combination. Ohio Bul. 513. 1932.

CHAPTER VIII

CULTIVATING CORN

THE average Corn Belt farmer with 50 acres of corn spends 300 hours of man labor and 600 hours of horse labor cultivating corn. At the same time, his team walks about 470 miles. This takes more time than any other farm operation except corn husking. Moreover, corn cultivation conflicts to some extent with haying and oat harvest. The principle of cultivation followed by most farmers is to cultivate the crop as many times as possible before the corn gets too high to work in. But they should keep in mind the reasons for cultivating and the cheapest, easiest ways of accomplishing the desired results.

CHIEF REASON FOR CULTIVATING

A large number of corn cultivation experiments have been conducted throughout corn-producing states. With but few exceptions, the tests show that in the cultivation of corn, the killing of weeds is the all-important object. The Kansas, Illinois, Minnesota and Missouri stations and the United States Department of Agriculture have obtained conclusive results showing the great importance of the weed factor. Corn hoed by hand to prevent weed growth, without stirring the soil, has yielded as much as corn thoroughly cultivated. As an example of such experiments, those at the Kansas station, conducted upon a heavy silt loam, are represented by the following tabulation of the average yields of corn variously cultivated in 1914 to 1921.

TABLE XIII

METHOD OF CULTIVATION TEST SUMMARY, 1914–1921

	1914	1915			1916		1917		1919	1920	1921	Av. of 7 Yrs.
		Upland	Bottom	Fall Plowed	Spring Plowed	Not Plowed	Fall Plowed	Not Plowed				
Ordinary cultivation.	13.0	60.1	70.0	44.7	43 9	45.3	44.4	34 9	27.7	74 8	60.1	47.0
Ordinary cultivation plus one-horse cultivator, as per judgment. . .	13.3	57.3	66 7	44.5	46.5	39.0	45.4	33.5	26.1	77.5	63.9	46.7
Ordinary cultivation plus one-horse cultivator every 10 days. .	11.0	52 1	65 5	42.7	46 1	41.5	44 8	34.4	24 3	76 3	64 5	45.8
No cultivation, weeds scraped.	9 2	58.6	71 4	44 0	46 8	45 0	40 6	29 4	25 7	73 8	65 7	46 6

At the Illinois station, as an average of nine years, keeping the weeds scraped off with a hoe without stirring the soil gave a yield of 48.9 bushels, as compared with 43.3 bushels for three shallow cultivations. In the years of plentiful summer rainfall, the three cultivations usually yielded somewhat better than shaving the weeds off with a hoe, but in years of low rainfall, it seemed that killing the weeds without stirring the soil gave the highest yield. In another Illinois experiment lasting for six years, it was found that, on soil which was not fertilized, the hoe-scraped corn yielded slightly more than corn cultivated with either blades or shovels. When fertilizer was added, however, the hoe-scraped corn yielded 55.6 bushels per acre, as compared with 58.1 bushels for blade cultivated corn and 59.5

bushels for shovel cultivated corn. These Illinois experiments indicate that on ordinary Corn Belt soil, cultivation is useful only in so far as it kills weeds and that in dry seasons or on soils which are the least bit low in fertility, cultivation, by preventing the corn roots from feeding on the 2 or 3 inches of rich surface soil, causes positive damage except for the weed killing. Of course, no practical farmer will ever keep the weeds down in his corn by hoe-scraping, but as a result of these experiments he will cultivate his corn only to the extent that is necessary to kill weeds most effectively without hurting

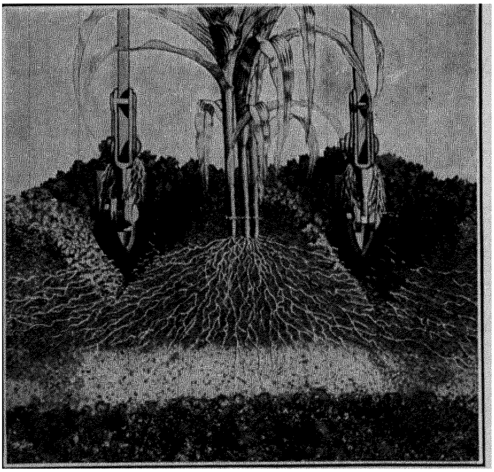


FIG. 32.—Showing how deep cultivation cuts the corn roots.

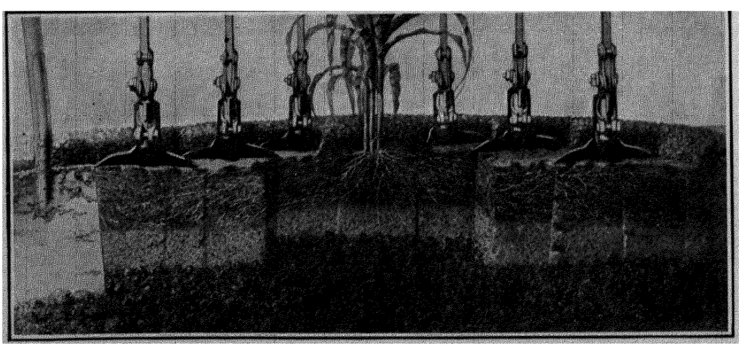


FIG. 33.—Illustrating how surface sweeps do not cut corn roots in the same way as big shovels.

the corn roots. It is only on a few very heavy soils that cultivation in addition to killing weeds is a positive benefit in letting air into the soil and thus enabling the corn to grow better as a result of the action of nitrifying bacteria. When soils crack badly during a drouth, cultivation may, by filling up the cracks, conserve some moisture which otherwise would

FIG. 34.—Rotary hoe working in small corn.

be lost. On most corn soils, however, the one object of corn cultivation is to kill weeds most effectively.

Other reasons for cultivating.—At various periods throughout the history of corn cultivation, several other beneficial results have been attributed to proper cultivation. Some of the common reasons are to:

1. Conserve moisture.
2. Make plant food more available.

3. Retard soil erosion.
4. Mix the soil constituents.
5. Improve the physical condition of the soil.
6. Germinate dormant weed seeds.
7. Give the plants a loose soil in which the roots will grow better.
8. Cover organic matter.
9. Control the soil temperature.

Under some conditions any or all of these desirable factors may be accomplished to a certain extent. But, as previously pointed out, the killing of weeds appears to be the only factor that has a great effect on the crop that year or following years. Soils lose large quantities of soil water, but this loss is due chiefly to utilization by the growing crop, transpiration from growing weeds, or internal evaporation and escape of water vapor. Only methods of tillage which will prevent loss from these sources are of value so far as the water in the soil is concerned. Excessive run off may be retarded and the absorption of water by the soil may occasionally be aided by proper methods of surface tillage.

The Right Type of Cultivator

There are a large number of corn cultivators in use to-day. Different types are of special value for different conditions and times of cultivation. However, the right cultivator should be used at the right time and under the conditions to which it is adapted. Cultivators may be divided into the following classes:

1. Shovel cultivators—(*a*) with small shovels; (*b*) with large shovels.
2. Surface cultivators—blade or sweep.
3. Disk cultivators—(*a*) surface planted corn, (*b*) listed corn.
4. Harrows—(*a*) spike-tooth, (*b*) weeders.
5. Rotary hoe.
6. Miscellaneous cultivators—(*a*) one-horse, (*b*) hand hoe.

The first three classes may be divided again according to whether they are of the one-row or two-row type. The latter are becoming common. They are of particular advantage on

large areas and for later cultivations. The two-row cultivator reduces the time required for cultivation about 45 per cent. Care must be employed when using the two-row cultivators for the first cultivation and in crossing checked corn. Another classification may be made according to whether the cultivators are horse or power drawn. At the Missouri station it required forty-two minutes to cultivate 3 inches deep an acre of 12-inch

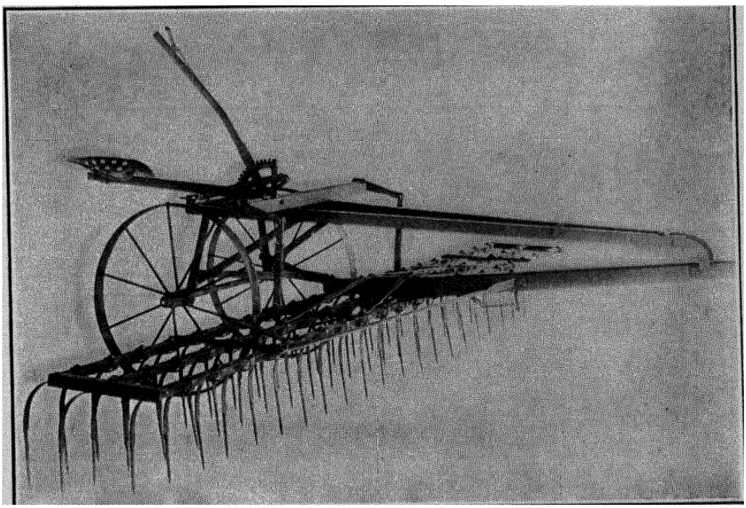


Fig. 35.—The weeder is a tool often used instead of a cultivator the first time over.

corn the third time with a two-row motor cultivator. The cultivation required three-fourths of a gallon of gasoline and one-tenth of a quart of oil for each acre. On the larger farms three-row and even four-row tractor cultivators are beginning to come into use.

The first shovel cultivators were large, and each gang of the machine carried only one shovel. These large shovels stirred the ground deeply and did considerable injury to the root system of the crop. The tendency in making shovel culti-

vators has been toward smaller shovels with more of them on each gang of the cultivator. Small shovels are desirable for the later cultivations. There are various shapes of shovels, such as the duck-foot, spearhead and the common or rectangular (sometimes called bull-tongue).

Surface cultivators are characterized by long sweeps or blades that work just under the surface of the ground. Surface cultivators are of particular advantage in the later cultivations. Many corn growers, therefore, substitute blades for shovels on their cultivators after the second cultivation. Large imple-

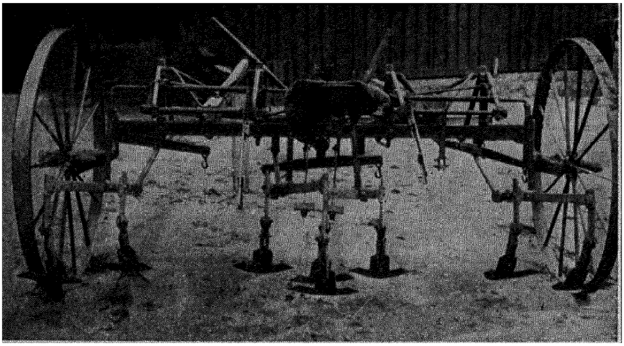


FIG. 36.—Two-row cultivator with duck-foot shovels.

ment concerns state that surface cultivators should be more widely used on loam soils, but that they have grown slowly in popularity because farmers have been accustomed by long usage to the shovel type. The surface cultivator has not found favor in sections of heavy clay or other tight soils. It is an excellent cultivator with which to fight morning-glories, Canada thistles and similar types of weeds.

The disk cultivator is the best type to use on weedy, grassy and sod ground. The disks will cut heavy growth that the shovels will not work in. Most cultivators used in listed corn are of the disk type.

Harrows are excellent for early cultivation. Many weeds

may be killed and a large amount of ground cultivated at a low cost with the harrow. Corn may be harrowed right after planting, before it is up, and until it is a foot high. The only time there is any danger of injury to the corn is when the field is harrowed at the time the plants are just coming through the ground. Harrowing will often take the place of one ordinary cultivation. Also, weeders cover a large amount of ground and cultivate corn efficiently, especially when the corn is small.

Another type of tool which gives much the same results as the weeder and harrow is the rotary hoe. This is splendid to destroy weeds which are just germinating while the corn is less than a foot high. The rotary hoe used at frequent intervals during late May and early June makes it possible to lay corn by with only two regular cultivations.

There may be times after the corn is " laid by "—given the last ordinary cultivation—when additional single horse cultivation is beneficial. In such case, a special type of one-horse cultivator may be used, or a mower wheel may be dragged through the field. Hand pulling or hoeing of persistent weeds after the corn is " laid by " should be practiced.

TABLE XIV

IMPLEMENTS USED IN CULTIVATING CORN (ILLINOIS STATION)

(Bushels per Acre Produced)

Implements	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	Av.
Small shovels...	61.7	47.5	44 3	48 0	33.2	67.3	47.2	53 2	36 9	53 0	49 2
Large shovel....	61.0	45.2	42.6	45.2	29 1	62 4	47.5	57.8	37 7	54 0	48.2
Tower cultivator	64.0	42.1	43.1	51.6	33.2	67 1	50.2	53.9	38 1	49 3	49.3
Disk cultivator.	64 4	44.3	46.7	48.8	35.6	67.5	47.2	55.1	29.0	56.8	49.5

CULTIVATION PROCEDURE

The first cultivation may be made before the crop is up. While the harrow is more commonly used, some farmers prefer

to "blind plow," following the planter marks with the ordinary cultivator before the corn is up. Blind plowing is desirable in fields infested with quack grass or similar weeds. In many cases farmers neither blind plow nor harrow, but begin cultivation with the ordinary cultivator after the corn is about 4 inches high.

FIG. 37.—Two-row cultivator in action. With corn of this size it does good work with one-half as much man labor as a single row cultivator.

The first cultivation is always in the same direction as the corn is planted. Care should be taken that the young plants are not injured or covered. Either stationary or rotating shields on the cultivator will help to protect the plants from being covered by loose soil. Plants partly or entirely covered at the time of the first cultivation are permanently stunted and are either barren or produce nubbins.

The cultivator should run deeply and close to the row the

first time over, so as to cover weeds in the hills. The kernel contains food on which the plant feeds when it starts, hence the roots have not yet grown out where many of them will be disturbed. The first cultivation is the most important. If it is deep and close to the corn plants, it helps to warm the soil, destroys weeds, and loosens the ground so thoroughly that the later plowings are easier.

In checked corn the second cultivation is usually crosswise of the direction the corn is planted. The ease or difficulty of this cultivation is dependent upon how accurately the corn was checked in planting.

After the first cultivation, it is not advisable to run the shovels too deeply or too close to the hills. Allow them to throw in just enough dirt to cover weeds in the hills. A month after planting, the roots from hills, side by side, may be found to meet each other between the corn rows and to be within $2\frac{1}{2}$ inches of the top of the ground 6 inches out from the hills of corn. Plowing deeper than 3 inches close to the hills at this time tears many roots and injures the corn.

Practical farmer advice.—A farmer from Guthrie county, Iowa, describes his methods of corn cultivation as follows:

"We use the six-shovel, balance frame type of cultivator. We have tried surface plows, but found them impractical for a heavy loam soil such as ours. Always have the shovels well sharpened. We put our plows on a level floor, placing the wheels on 5 or 6 inch blocks, raise the tongue to position and do our adjusting before going to the field. This saves time when in the field, as only slight changes are necessary, and we know just what we are doing, which is almost impossible with adjusting in the field, especially if the team is restless.

"For the first cultivation, set the beams as close together as possible. The front shovels are set slightly deeper than the others to allow for deep plowing without making 'ditches' with the rear shovels. The front shovels are turned out to throw the clods and most of the dirt away from the corn, while with the shields correctly adjusted just about the right amount

of fine dirt is rolled to the row to cover the weeds, with a minimum amount of corn covered.

" Another advantage of this is that in wet spots or hard places, no ' slugs ' ever go over the shields onto the corn. The second shovels should be set straight or turned a little out, never turned in, or they are liable to cover the corn from behind the shields. The rear shovels should be turned in just enough to balance the ' pull.' A properly set beam should run straight with no pull either way. We plow as deep as possible and close to the corn the first time. The second time we plow about the same depth and a little farther from the corn, raise the shields and turn the front shovels about straight. We average from seven to nine acres a day the first two cultivations. The third time we raise the front shovels a little and turn them in, discard the shields and plow farther from the corn, to keep from cutting the roots.

" The last plowing we spread the beams as far as possible and plow very shallow. I like to lay the corn by as large as possible because this leaves a clean field with the ground well shaded. Weeds must be taken care of by the first two cultivations. Plowing deep the last two times is sure to injure the corn roots. We use spearhead shovels on one cultivator and common shovels with sweeps for the last plowing on the other. Theoretically, sweeps are best for the last cultivation, but in practice spearhead shovels are nearly as good. They throw plenty of dirt, but not too much, and cut more weeds and have lighter draft than common shovels. We find that corn yields best with four cultivations, as the field is kept cleaner and pests do not have a chance to work on it on account of the frequent stirring."

Determining the Method of Cultivation

In general, there are two methods of cultivation: (1) level cultivation, (2) hilled or ridged cultivation. Level cultivation

is better. Compared to the ridged type of cultivation it has the following advantages:

1. Less surface is exposed for evaporation.
2. Only shallow cultivation is required.
3. The field is more easily prepared for the next crop.
4. Yields are usually greater.

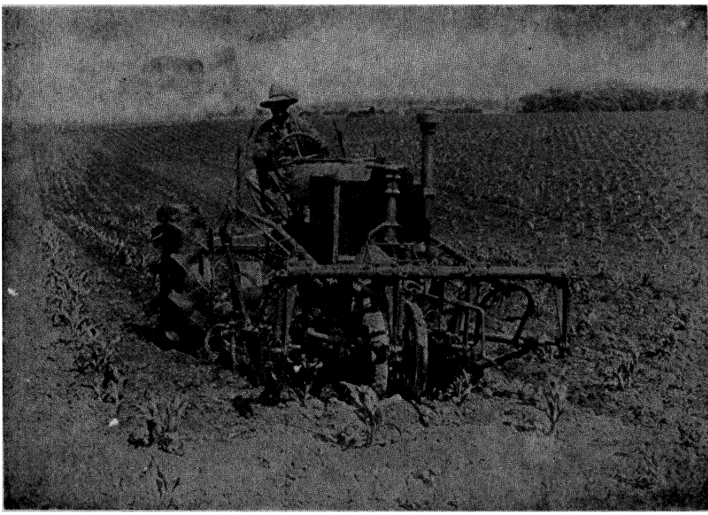


FIG. 38.—Two-row tractor cultivator at work.

Ridging may sometimes be justified if the dirt thrown into the row covers a lot of foxtail which would otherwise get a start.

Depth of cultivation.—Occasionally cultivation four or more inches deep kills weeds more effectively than shallow cultivation, but as a rule deep cultivation is no more effective than shallow cultivation in killing weeds, and the yield is less because of the damage done to the corn roots. Moreover, deep cultivation keeps a high percentage of the rich surface soil so dry that it is not available as plant food to the corn roots. In the case of very rich soils heavily fertilized, the Illinois experiments referred to early in this chapter indicate that moderately deep

cultivation may cause no damage. In a six-year comparison between deep and shallow cultivation at the Illinois station, it was found that the shallow cultivated corn yielded more, four out of the six years, and that as an average of the six years the yields were 70.3 bushels for the corn cultivated shallow four or five times, and 66.7 bushels for the corn cultivated deep four or five times. It is common-sense practice to cultivate moderately deep the first time and rather shallow after the corn has reached a height of 1 foot or more.

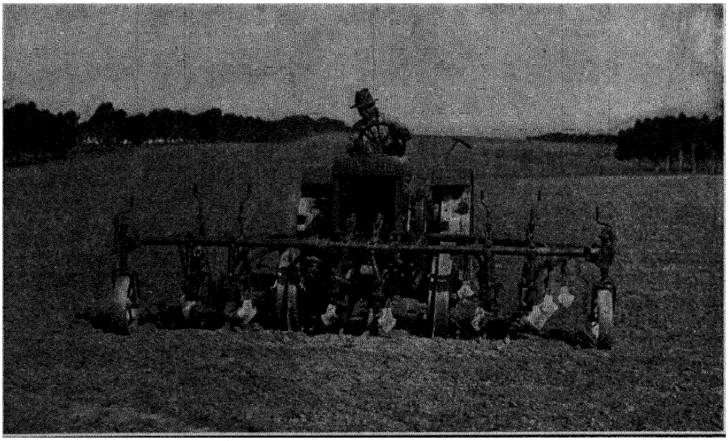


FIG. 39.—Cultivating three rows of corn with a tractor.

How cultivation affects soil.—The cultivation must be suited to the kind of soil. If a field is sandy or easy to work, because it is rich in organic matter, it may be plowed from the beginning with a surface cultivator. Wet, heavy soils should be given deeper cultivation the first time to loosen them up and dry out the surface. If a shovel cultivator is used, it should not run as deeply the second time. A surface cultivator may be used on heavy soils of this type unless there have been heavy rains to pack the soil.

Number of times to cultivate.—The number of times to cultivate corn will depend upon the number and kind of weeds, the ground in which it grows and the climatic conditions. Keep the corn free from weeds, and try to keep the dirt on top loose—to hold moisture. The growth of weeds in many cornfields shows that such fields are suffering from a lack of cultivation. In others the soil is baked and moisture is lost. When the ground gets too dry after heavy rains, it will dry and crack open.

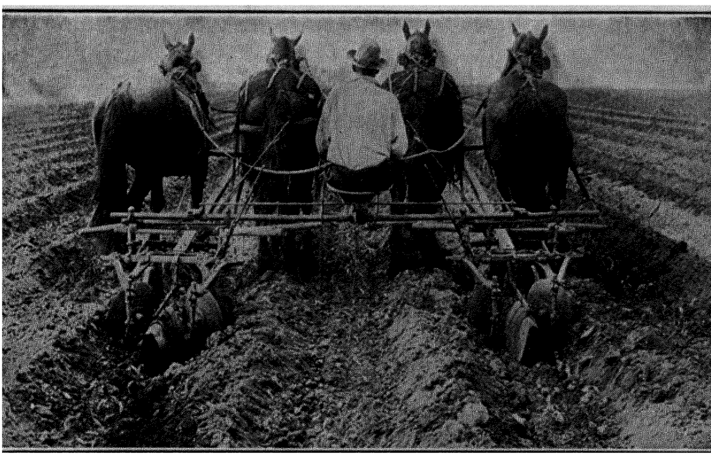


FIG. 40.—Lister two-row cultivator, illustrating method of throwing dirt away from the plants in the furrow the first time over. When the plants are larger the dirt will be thrown toward them.

These cracks allow the moisture to escape rapidly, and should be prevented by cultivation. After the corn grows tall, its foliage shades the ground from the sun, and largely prevents both the loss of moisture by evaporation and the growth of weeds. Sometimes, when the season is warm and wet, the corn may grow so fast it is cultivated only twice. The usual number of cultivations in the Corn Belt is three.

Cultivation of listed corn.—Disk cultivators are commonly used to cultivate listed corn. The disks are set to cut and throw

out the weedy fringe the first time over. A hooded shield is used to protect the plants, especially the first time over. Small shovels are set to mulch the soil in the furrow close to the corn, and large shovels are set to destroy weeds on top of the ridge. The second time over, the corn is a few inches high, and so the disks are set to throw in, filling the furrow. The shovels are set to destroy and work down the ridge. The disk cultivator is used two or three times, depending on conditions. Often listed corn is "laid by" with an ordinary shovel cultivator. Both single-row and two-row lister corn cultivators are used.

Ways of reducing cost of cultivation.—Harrow and disk the field thoroughly before planting, to kill weed growth in its early stages and to make the seed bed firm. If most of the weeds are killed before the crop is planted, later cultivations may be reduced to a minimum. Good preparation of the seed bed will lessen the cost of cultivation. The use of the harrow or weeder for early cultivation is one of the most important labor-saving practices. Two-row cultivators save man labor. Remember that the one big object of cultivation is to kill weeds.

Acres cultivated per day.—Under Corn Belt conditions, the average number of acres cultivated in a ten-hour day is about as follows:

One-row riding (first or second cultivation), one man, two horses	5.5
One-row riding (third cultivation), one man, two horses	7.0
Two-row riding, one man, three or four horses	13 0

A Kansas farmer reports that with a two-row lister cultivator of the type illustrated in this chapter, sixteen acres can be cultivated in a ten-hour day.

WEEDS—PREVALENCE AND METHODS OF CONTROL

As the killing of weeds is the chief task in cultivation, the grower should be able to identify the weeds of his cornfield and to know the most feasible method of controlling them. Good corn growing is a constant battle against weeds, and the

weed factor is a large one in determining the number of acres of corn to grow. Weeds deprive corn of both moisture and plant food.

Although weeds are one of the worst enemies of corn the cornfield is an excellent place to eradicate weeds that have become a pest in meadows, pastures and small grain. In sections where corn or other cultivated crops can not be profitably grown, the weed problem is a difficult one. To rid their fields of weeds, the farmers must summer fallow, thereby losing the crop for one year. Corn growing is partially replacing summer fallow in many sections, because clean cultivation of corn frees the ground of weeds and the small western corn is not a heavy user of moisture. The spring-seeded grain crop following corn does nearly as well as after summer fallow, thus showing the importance of killing weeds.

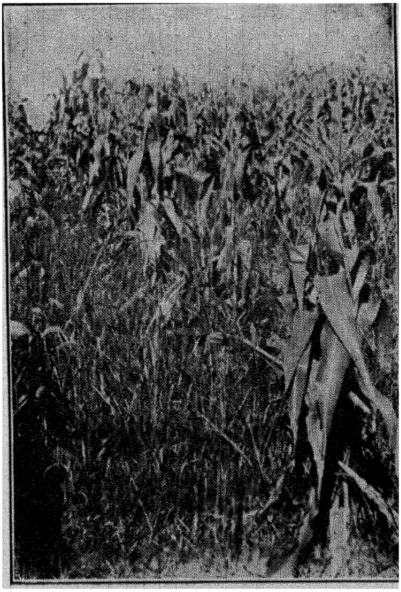


FIG. 41.—Poor cultivation in June gave foxtail and barnyard grass such a start that the yield of this field was reduced twenty bushels per acre.

Influence of weeds on yield.*—The most important factor in the growth of a crop of corn on fertile soil with a well-prepared seed bed in humid regions is the killing of weeds. With the same preparation of seed bed, corn produced, as an eight-year average, 7.3 bushels per acre where the weeds were allowed to grow, and 45.9 bushels where the weeds were kept down with-

* Illinois Bulletin No. 181.

out any cultivation. This gives an increase of 38.6 bushels, or say $19.30 per acre, for keeping weeds down. Weeds deprive the plant of moisture, light and food, all of which are absolutely necessary for the production of crops.

The classes of weeds.—Some weeds produce enormous quantities of seeds, some produce strong underground stems (quack grass) or roots (Canada thistle), that produce new plants, and others produce both seed plentifully and strong underground systems. The weeds of corn may be classified according to the length of their life as follows:

1. Annuals—those that live one year, such as foxtail and crab-grass.
2. Biennials—those that live two years, such as bull thistle and wild carrot.
3. Perennials—those that live more than two years, such as Canada thistle and quack grass.

The annuals and biennials are usually easy to kill by cultivation, because they grow only from seed. If new weed seeds are kept off the farm, and the weeds already growing are prevented from going to seed, no great amount of trouble will be had from these. Most of the perennial weeds are propagated by underground parts as well as seeds, and the job of eradication is more difficult. To eradicate these weeds, all top growth must be kept down, so that the underground parts will starve. Care must be taken in cultivation so that underground parts are not spread by the cultivator, for small pieces take root and form new patches of the perennial weed.

Use of smother crops to kill weeds.—There are many smother crops that will control weed growth or at least weaken the growth of the weeds so that the pests may easily be eradicated by proper cultivation. Alfalfa, Sudan grass, buckwheat and sorghum are good weed exterminator crops. A heavy seeding of oats acts as a smother crop. For smother crops to be effective, the seed bed must be clean at time of sowing. Fall plowing and thorough cultivation with the disk in the spring, followed by shallow plowing before seeding, check the weeds

severely. The oats should be cut early for hay, before the weeds mature seed. After the removal of the crop, the ground should be disked and plowed.

Common cornfield weeds.—Some of the worst cornfield weeds from the standpoint of number, difficulty in eradication or damage to the corn crop, are:

Perennials

1. Canada thistle. *Cirsium arvense.*
2. Quack grass. *Agropyron repens.* (Northern Corn Belt).
3. Wild morning-glory (Bindweed). *Convolvulus sepium.*
4. Horse-Nettle. *Solanum carolinense.*

Annuals

1. Black bindweed (Wild buckwheat). *Polygonum convolvulus.* (Northern Corn Belt)
2. Cocklebur. *Xanthium canadense.*
3. Indian mallow (Butter-print or velvet weed). *Abutilon theophrasti.*
4. Pennsylvania smartweed (Heart's-ease). *Polygonum pennsylvanicum.*
5. Lady's thumb. *Polygonum persicaria.*
6. Foxtail (green and yellow). *Setaria viridis and Setaria glauca.*
7. Crab grass (Finger grass). *Digitaria sanguinalis.*

There are many other weeds often found in the cornfield, such as European bindweed, which is one of the worst of all when it gets in a field, milkweed, shoofly, lamb's quarter, wild sunflower, barnyard grass, artichoke, ragweed, pigweed and Russian thistle (only in western part of Corn Belt).

Methods of control.—These weeds of corn are classified in four groups, as follows:

1. Weeds which require a special type of shovel on the corn cultivator.
2. Weeds which can not be handled to the best advantage unless the land is put into meadow or pasture for a time.
3. Weeds which require a thorough hand hoeing during late July or early August.
4. Weeds which are common in every cornfield but require no attention other than the ordinary three or four cultivations.

First group.—The first group includes weeds like the Canada thistle, wild morning-glory, and European bindweed and other weeds that grow from underground running roots and from seed. These running roots branch and grow horizontally from the main root. They may be found from a few inches to a few feet below the surface of the soil. At almost any time during the growing season, buds will form on these horizontal roots and send up new plants. The above-ground growth manufactures the food material that is stored in the roots. In order to starve out the plants, it is necessary to keep down all top growth. If the underground growth is not replenished by food which is made only by the aid of green leaves, all of the food in the underground roots will be used by the growing plant. In time, the plant and roots will die. It is necessary to watch for the introduction of new plants from seed.

Fig. 42.—Canada thistle.

Frequent cultivating with spearhead, surface, or duck-foot shovels is necessary so as to keep down the top growth of the weeds in this group. After cultivation is discontinued, the patches of these weeds should be kept down by hoeing. Localized patches where there is a thick stand may be summer fallowed and a crop grown on the remainder of the field. Where thistles are not too firmly established, smother crops, such as alfalfa, grasses, millet and small grains thickly sown and grown

for one season give these weeds a setback which makes easier the eradication by clean cultivation in the cornfield the following year. The plants are easily spread by root-stocks that hang on the cultivator shovels.

Second group.—In the second group are weeds such as quack grass and Johnson grass which spread by underground stems in the same way as the first group. It seems necessary to put a field that is badly infested with these weeds into meadow or pasture for a term of years. The pasturing or continued cutting of these grasses brings the underground stems closer to the surface of the ground. Exposing the underground stems by plowing will kill many of the plants. The following crop of corn will afford a good place for thorough cultivation and liberal use of the hoe. This method of control may also be used for the first group.

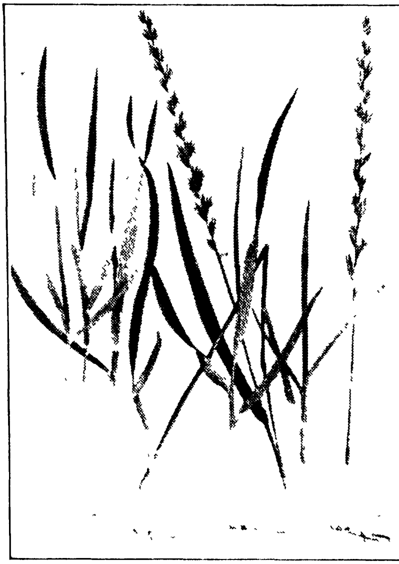


FIG. 43.—Quack grass, a bad cornfield weed in the extreme northern part of the Corn Belt.

Third group.—Persistent annual weeds, such as the cockle-bur, butter-print, black bindweed, and the Russian thistle are weeds that should be handled by the third method. Ordinary cultivation will not kill all of these weeds in a cornfield where they have a good hold. It will require thorough cultivation plus hoeing and hand pulling during late July and August to clean a field. Weeds of this type set an abundance of seed, and so every plant should be eradicated. Plants of the cocklebur a few inches high will mature seed. The bur of this weed encloses

a pair of seeds, one of which will germinate one season and the other the next season. The seed of the butter-print lives in the soil for ten or more years.

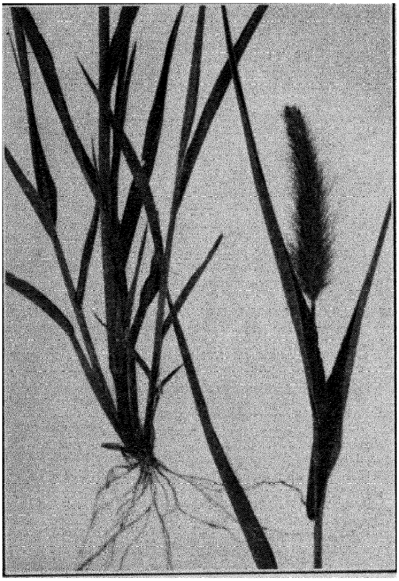


FIG. 44.—Foxtail, the most widespread annual weed in corn.

Fourth group.—Most of the ordinary annual corn-field weeds are in this class. The most common weeds of this group are the Pennsylvania smart-weed, lady's thumb, fox-tail, shoofly, crab grass, lamb's quarter, and pig-weed. Thorough preparation of seed bed and cultivation as outlined above will rid badly infested fields of these weeds. Heavy June rains which delay the first or second cultivation permit annual weeds of this type to become very serious. In this case, the only practical thing which can be done is to cultivate as quickly and cleanly as the weather will permit. Heavy late summer rains often cause a rank growth of these weeds in August, even though the field was clean at the time of " laying by." Such a growth is not serious, and there is nothing practical to do about it.

Selected List of References

CATES, J. S., and COX, H. R. The Weed Factor in the Cultivation of Corn. U. S. D. A. Bur. Plt. Ind. Bul. 257, 1912.

HELM, C. A. Corn in Missouri. Mo. Bul. 185, 1921.

WIMER, D. C., and HARLAND, M. B. The Cultivation of Corn, Ill. Bul. 259, 1925.

SALMON, S. C. Corn Production in Kansas. Kans. Bul. 238, 1926.

KIESSELBACH, T. A., ANDERSON, ARTHUR, and LYNESS, W. E. Tillage Practices in Relation to Corn Production. Nebr. Bul. 232, 1928.

CHAPTER IX

CONTROLLING INSECTS AND DISEASES

INSECTS OF CORN

INSECTS that attack corn are numerous, but most of them do not cause serious damage. Occasionally local attacks are severe and the entire crop of a community will be destroyed as a result of the work of a particular insect. Control measures, to be practical, should be simple, cheap and easily applied.

Most common corn insects have four stages in their life history, which may last a part of a year, one year or several years. The four stages are the egg, larva, pupa and adult stage. An adult insect usually deposits several hundred eggs and its function in life is completed. The eggs, as a rule, hatch out quickly into the larval or worm stage. After the worm finishes feeding, it turns into the pupal or resting stage. From the pupa emerges the adult as the butterfly does from the cocoon. Some insects such as the aphis bear live young.

The description of the insect, its life history, the character of damage done and the control measures are given of the important insects of corn in the Corn Belt. The insects are divided into five classes, those that work primarily on: (1) the roots, (2) stalks, (3) leaves, (4) entire plant, (5) stored grain.

INSECTS THAT WORK ON THE ROOTS

Wire-worm.—The common wire-worms are reddish-brown in color, hard and rather shiny in appearance, cylindrical in shape and an inch or more in length. The adults are boat-shaped fellows, one-half to three-fourths of an inch long and brown or

black in color. They are known as "click beetles" or "snapping beetles," from the snapping noise they make when on their backs.

The wire-worm changes to the pupal stage in July or early August. Only two or three weeks are spent in this stage before changing to the beetle. The beetle, however, spends the winter in the pupal cell and comes out the next spring. It deposits its eggs in the soil. The larvae hatch out in a few days and begin feeding. The corn wire-worm may spend as long a time as five years in the soil, while the wheat wire-worm spends only three.

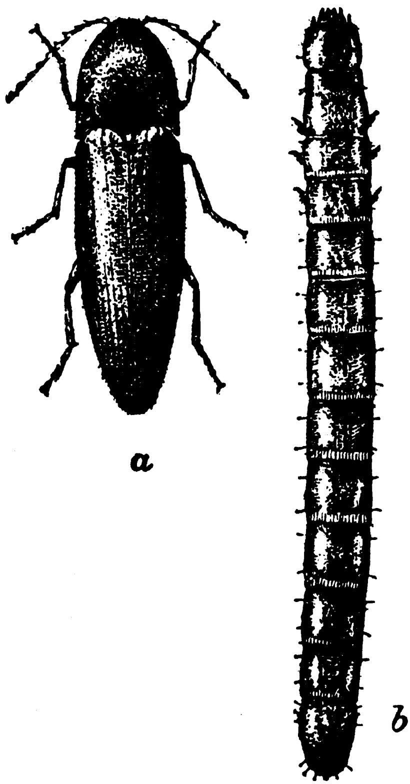


FIG. 45.—(*a*) Wire-worm beetle or click beetle. (*b*) Wire-worm (*much enlarged*). The full-grown wire-worm is only about $1\frac{1}{2}$ in. long.

The failure of seed to sprout or the withering of corn plants at 2 feet or less in height often indicates wire-worm attack. Wire-worms feed first on the seed itself, later on the roots. If the affected field has been in grass a year or so previous, the injury is most likely to be that of wire-worms. The larvae do not cause any visible injury to grass. However, when grass land is put into corn, the wire-worms concentrate upon the hills of the planted grain and cause much damage.

Wire-worms are difficult to control because (1) they work underground; (2) they cling to life; (3) there are several injurious species of wire-worms requiring different methods of control.

There are many useless or impracticable control measures often recommended. They are: (1) coating the seed with various poisons or repellents, such as tar, kerosene, Paris green and strychnine—an Iowa county agent says the insects enjoy and eat the protected kernels more readily; (2) treating the soil with salt; and (3) plowing late in the fall. There seems to be no practical way of controlling wire-worms aside from substituting clover for timothy in the rotation and leaving the land in clover only a year or two.

Corn root aphis.—The corn root aphis or root louse is a tiny blue-green adult. The root lice which hatch from the eggs in the spring are all the same sex, females, which produce during the summer ten to twenty generations of live young. These females are found throughout the spring and summer and the males do not appear until the fall. The root lice multiply very rapidly and cause much damage to growing plants. Most of them are wingless, but occasionally winged forms are found. In the fall, both males and females appear. Mating takes place and the females deposit eggs, instead of producing young. These eggs are taken up by the little brown ants, which care for them in their nests during the winter. The root lice are very well cared for by the ants, because the aphis secretes a sweet substance, "honey-dew," of which the ants are fond.

The presence of the corn root aphis in a field of growing corn is usually shown by (1) a dwarfing of the plants and a yellowing or reddening of the leaves; (2) finding numerous ant hills near affected stalks; (3) the presence of many lice on the main roots. The tiny lice suck the juices from the roots, thereby weakening the growth and reducing the yield.

Crop rotation is the most effective measure against the root aphis, although it feeds on other plants than corn. Where crop rotation with only one or two consecutive crops of corn is prac-

ticed, little injury occurs. With the exception of cotton in the South, the other crops grown are not much affected, as corn is the favorite food of the corn aphis. If it is not practical to rotate, deep and frequent cultivation early in the season may help.

Seed treatment methods have not proved practical.

Corn root worm.—The root worms are small, slender, white grubs, about half an inch long when full grown. The northern form of the root worm in its adult stage is a plain grass-green beetle, about one-fifth of an inch long. The beetle of the southern root worm is green, with twelve black spots on its back. It is also somewhat larger than the plain green beetle, measuring nearly a quarter of an inch long.

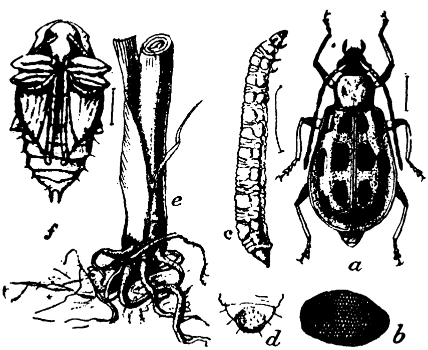


FIG. 46—(*a*) Corn root worm beetle. (*b*) Egg. (*c*) Corn root worm whose feeding causes most of damage. (*e*) Base of young corn plant with entrance hole of root worm. (*f*) Pupa or resting stage that precedes the beetle. (Enlarged).

In the fall, the beetle of the northern form may be seen on the silk of corn and the flowers of the golden rod. The beetles deposit their eggs in the soil near the stalks of corn. The next spring these eggs hatch out early. The young root worms begin to attack the corn almost as soon as it is out of the ground. Throughout the summer, the larvae work on the roots. When the larvae mature, they change to the pupal stage, in which they spend only a short time. The plain green beetle emerges from this pupa and the life history is repeated. The black-spotted beetles of the southern corn root worm are found not only in the fall, but all through the season, from

early spring onward. There seem to be at least two generations of them during the year. The life history of the southern corn root worm is similar to that of the northern form, except that it is passed through in a much shorter time.

Corn is the only food plant of the northern root worm. On the other hand, the southern root worms have been found in wheat, rye, millet and other grasses. The northern form does more injury to the corn in the north. The withering of young plants and the blowing over of the stalks may be due to the root worm. However, more often these conditions are due to other factors.

If the plain green or the black-spotted beetles are seen in very large numbers feeding on the silks of the corn in August, it is an indication that a cornfield on the same piece of ground will be infested with the root worms the next year. Those fields should be planted to some other crop than corn, and the corn put on a new field. Rotation is an almost infallible cure for the northern corn root worm, but is not at all effective against the southern form.

White grub worm.—The grub is a large white insect with a reddish-brown head. It is similar to the grub found in manure piles, which, however, is not injurious to corn. The parent form of the white grub is the common May beetle or June bug, the large, black or brownish beetle which flies to the lights in May and early June.

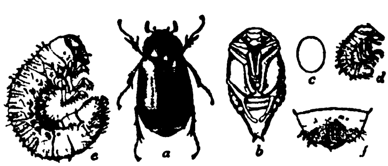


FIG. 47.—(*a*) June bug. (*e*) Full-grown white grub ready to pupate. (*d*) Half-grown grub at stage when it does the most damage to corn. (*Reduced.*)

The beetles hide in the soil all day and after sundown feed on the leaves of trees, often doing considerable damage. They deposit their eggs in rather compact soil, usually sod ground, during June. These eggs hatch and the young grubs begin to feed

upon the roots of the grass that summer. Grubs of most species do not become full grown for two years, and even then they remain in the soil for a third winter, emerging as beetles nearly three years after the eggs were deposited. A generalized life history is as follows:

First year—In May the beetles emerge from the soil, feed, and deposit eggs. Larvae hatch, begin to feed, and winter over in the soil.

Second year—Larvae feed during the season. The most damage to crops is caused this year. The larvae winter over in the soil practically full grown.

Third year—Larvae feed early in the season, pupate in June or July, and change to beetles a few weeks later. The beetles stay in the soil over winter.

Fourth year—Same as the first. Beetles emerge in May and early June.

A few common species complete their life cycle in two years.

The presence of the white grub is indicated by (1) dwarfing of the plant, (2) killing of the plant in any stage of growth, (3) weak root system, (4) falling of the stalk. The grubs are not known to infest such crops as clover, alfalfa, or buckwheat; these may safely follow sod in a "grub year." Small grains are attacked by the grubs, but to a less extent than corn or potatoes.

Under certain conditions, grubs may be controlled by an intelligent rotation, particularly in a district known to be badly infested. Grubs are usually abundant near wooded areas. When grubs are expected in any particular year, corn should not follow sod. It may safely follow a cultivated crop. By referring to the generalized life cycle, one may determine when to expect damage by grubs. For instance, if the beetles are exceptionally abundant one year, a large number of grubs may be expected the next year. In any given locality, the grubs are likely to be numerous at three-year intervals. For example, northeastern Iowa has had outbreaks in 1912, 1915, 1918, 1921, 1924, and 1927. If the two-year-old grubs are damaging corn, there is no practical measure to get rid of them at

once without injuring the crop. However, such measures as fall plowing, rotation, and turning hogs in on grub-infested land may partially prevent further injury. Hogs turned into infested fields by the middle of October, before the grubs go deep, will rapidly clear out most of them. The only objection to turning in hogs is that occasionally they become infested with the thorn-headed worm, which is a parasite of both hogs and white grubs. Because the grubs go deeper into the soil for the winter, early fall plowing is of some value, as it brings the grubs to the surface and crushes many of them.

Insects that Work on the Stalks

Cut-worm.—Full-grown cut-worms are about one and one-half inches long, usually dull in color. Rarely, as with the variegated cut-worm which attacks clover, are they well marked or striped. Late in June or early in July the mature larva forms a loose cell in the soil, changes to the pupal stage, and a few days later to the adult or moth. Moths of the various species are much alike. All are dull in appearance and brown or gray in color, with the hind wings lighter than the fore wings.

The moths deposit eggs in the grass lands late in the season. The larvae hatch the same fall and spend the winter in the soil, partly grown. Consequently, they are of good size by the time the young corn plants are pushing their way through the ground. Except in the south, there is usually only one generation each year. A few important species pupate in the fall.

The cutting off of the stalk at the base of the plant, at or just below the surface of the soil, is the work of cut-worms. Usually, the insect responsible for the damage may be found in the soil near the plant attacked.

If cut-worms are present in a cornfield, the only two measures to be taken are replanting and poisoning. Replanting should be delayed until damage by the insects has practically

ceased. Although the cut-worm pupates in late June, it usually does very little severe damage after warm weather comes on in early June. A poison bait may be made by mixing 1 pound of Paris green with 25 pounds of dry bran or middlings. Scattered over a cornfield, this bait attracts the cut-worms, which feed on it and are killed. Results are sometimes very good, but occasionally this method seems to be worthless.

Early fall plowing of grass land to be planted in corn the next year is a preventive measure. This plowing buries the eggs or young larvae so they can not live over winter. Close fall pasturing of such land is also a benefit. Corn land should be disked and harrowed as much as possible before planting.

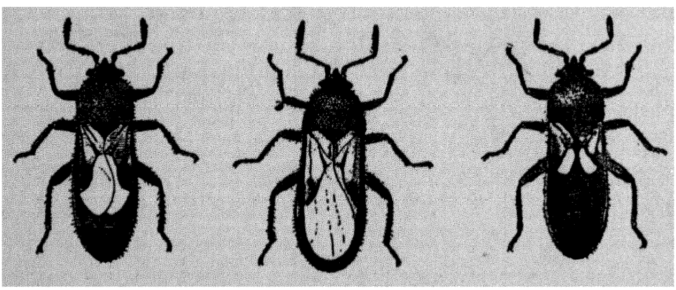


FIG. 48.—Adult winged forms of chinch bug. The larval form, which invades cornfields, looks like this, but has no wings.

Chinch bug.—The adult form of the chinch bug is about one-fifth of an inch long, black in color, with the under wings whitish. These wings cross on the back of the insect, forming a sort of an X-shaped mark. Young chinch bugs are pale yellow at first, becoming quite reddish later. At first, there are no traces of wings, but in the later stages wing pads appear. Chinch bugs shed their skins four times and after the fourth moult become full grown.

During the winter, chinch bugs hibernate in clumps of grass and along fences and hedge rows. In April or May they go to the fields of small grain, which offer plenty of food at this time. They soon deposit their eggs, and their young feed on

the grains. At harvest the bugs of the preceding year are dead and the young ones have not developed wings. The bugs seek green food, and since they are unable to fly, they crawl from one field to another. Growing corn at this time is especially tempting to the partly grown chinch bugs, and the object of the control measures is to keep the bugs out of the corn. Chinch bugs mature in the cornfield in July and deposit eggs for a second generation. They grow rapidly and feed on the corn. In September, the second generation matures and spends the winter as adults. A partial third generation is produced in the more southern parts of the insects' range.

Between 1900 and 1923 most chinch-bug damage was to corn south of the southern Iowa line. Back in 1887, however, chinch-bug injury was noticeable in three-fourths of the counties of Iowa; a similar invasion began in 1933, becoming most serious in 1934-1935. Damage to corn occurs, for the most part, in mid-summer, when the growing bugs pass from ripening wheat to corn. It does not necessarily follow that the chinch bug will not become dangerous in localities where no wheat is grown, although that usually is the case. Chinch bugs drive their beaks into the plant tissue and suck the juices.

In general, the control methods for the chinch bug are: (1) cleaning all rubbish and waste places; (2) placing barriers around fields.

Since the chinch bugs hibernate in clumps of wild grass and similar places, much benefit may be obtained by burning rubbish along fences and hedge rows, in the winter, where this can be done with safety. Clean culture does away with hibernating places in a field.

As wheat harvest in an infested field draws near, measures to prevent the insects from entering the cornfield should be taken. This is best done by making barrier lines of some repellent, such as road oil or preferably creosote, around the infested field. The road oil barrier must be kept so sticky

that the chinch bugs can not cross it, but the creosote acts on account of its repellent odor. The strip of oil should be half an inch thick or more. To be most effective the oil or creosote lines should be placed just below the top of the sloping sides of a furrow thrown toward the corn. Post holes about 2 feet deep should be dug at intervals of about 20 feet, along the oil line in the bottom of the furrow. A little kerosene poured into these holes will kill the bugs that collect. These barriers must be kept freshened.

Creosoted building paper or untarred felts set on edge, and creosoted soft rope barriers, were quite successfully used during the great outbreak of 1934-1935. The paper has the advantage of remaining effective in windy weather when blown soil often forms bridges across the plain creosote or tar line.

Once the bugs are in a cornfield, spraying with tobacco extract or kerosene emulsion is the only measure available. This is usually impracticable.

The natural insect enemies of the chinch bug are not numerous, nor do they thrive in hot, dry weather. On the other hand, chinch bugs are the most numerous and thrive best under these conditions. However, the natural enemies have done much to reduce the number and extent of chinch-bug attacks.

In southern Illinois chinch-bug damage has been reduced by growing varieties of corn with unusually large, sturdy stalks, wide leaves, and more than usually vigorous roots. The Democrat or Champion White Pearl is probably the best of these varieties. Under conditions of moderately severe chinch-bug infestation, the Democrat will yield twice as much as Reid Yellow Dent, whereas, on the same soil, without chinch bugs, the Reid corn will usually yield two or three bushels more per acre.

Corn bill-bug.—There are several kinds of bill-bugs. Most of them are black or brown in color. All are beetles with hard backs and long snouts, which make the holes in the leaf blades. In the grub stage, the corn bill-bugs feed on the roots

of certain sedges and grasses. One of the most common small species feeds on timothy roots.

In general, the insects spend the winter in the beetle stage and work in this stage upon the young corn plants in the late spring. In the early summer, the beetles deposit their eggs on timothy, corn, and other grasses. The eggs hatch and the young grubs feed on the grass roots until early fall, when the adult beetles appear. Before changing to beetles the grubs enter the pupal stage for a short period.

The tender leaves injured by rows of holes cut across the blade are often the work of the corn bill-bugs. The injury occurs when the plant is a few inches high, and the leaf blade is still within the sheath of the cornstalk. The holes do not become conspicuous until the blade has grown out. Since the blade is curled up within the leaf sheath, one hole made in the leaf sheath means six or eight holes in the curled leaf blade. Corn planted on timothy sod or on land on which sedges are present and which has been infested with these grubs is likely to be damaged, especially if the sod has been turned under in the spring.

It has been found that the early fall or summer plowing of sod lands which are infested with these grubs greatly reduces the injury if corn is put in the field the following year. The stirring of the soil disturbs the insects so that they are unable to survive the winter.

Army worm.—The army worm resembles the cut-worm. The color varies from yellow to brown or black. There are three stripes, a middle black one and an upper and lower yellowish one, on each side. The worm pupates in the soil. The pupa gives rise in ten to twenty days to a moth. The moth is a night-flying insect and is often attracted in large numbers to light. The fore wings of the moth are yellowish-brown in color and are marked with a small white speck near their center. Each female moth is capable of laying about 700 eggs.

These eggs hatch into small green worms in about eight to twelve days. The young worms eat but little and feed close to the ground. They may be in a field in great numbers and still escape detection. The worms are nearly full grown before injury becomes serious. Three to five weeks are required for full growth. The worms then are one and one-half inches long and one-eighth of an inch wide.

While the army worms prefer to breed and feed in grass or small grain growing in low and moist parts of fields, they become so abundant and food material so scarce that the worms are forced to seek other places for their food. On such occasions, the worms migrate in vast armies and enter a cornfield if it is in their path. The migrating worms climb the stalks and strip the plants of their leaves. The worms hide during the daytime under clods of dirt and rubbish, and feed during the night.

There are several control measures for the army worm. Infested areas may be mowed, covered with straw, and burned. If migrating, the worms may be destroyed by spraying, by scattering poisoned bait, similar to that used for cut-worms, or by trenching, as described for the chinch bug.

Grasshoppers.—There are several species of grasshoppers. Almost every one is familiar with the ordinary adult which does the damage to crops. The habits of the usual species are much alike. The grasshopper has no larval stage. The grasshoppers usually lay their eggs in the fall of the year and then die. The eggs are laid in masses in the ground. As many as 127 eggs have been found in a single egg mass laid by one of the large species of hoppers. Each female ordinarily produces two egg masses. The eggs remain in the ground over winter. The following spring, during May and June, the eggs are hatched. The young insects feed and grow and at intervals shed their hard skin. After the skin has been moulted for the fifth time, the insect is fully winged and the females are ready to lay eggs.

Ordinarily, grasshoppers do not breed in cornfields, but may invade such fields from neighboring ones where alfalfa, grain, or grass is grown, or from unplowed edges of fields and roads. They eat the leaves, silks, and husks of the corn plant.

There are several control methods. Poison bait made as follows is good:

Bran or mixed bran and sawdust	25 pounds
White arsenic or Paris green	1½ pounds
Or liquid sodium arsenite (4 pounds to the gallon)	1 pint
Cheap molasses	2 quarts
Water	10 quarts

This amount of bait is sufficient to scatter over two acres. It should be scattered early in the morning.

Corn ear-worm.—The ear-worm is the common greenish or brownish worm that eats into the ears of both dent and sweet corn. The adult is a brown moth.

As there may be three or more generations in one year, and each female produces 200 to 300 eggs, this insect can increase rapidly. It passes the winter in the pupal stage. The moth emerges early in the spring and deposits eggs which hatch by the time corn is planted. The first two generations live on the leaves, but the third generation attacks the ears.

The ear-worm is especially damaging to sweet corn. In the South it plays havoc with the dent varieties. The young worm begins to feed on the silks and kernels at the tip end of the ear. The full-grown worm tunnels down the ear toward the butt end. The same worm feeds on the cotton boll, the tomato and tobacco bud, vetches, alfalfa and many uncultivated plants.

There appears to be no reliable measure for controlling the corn ear-worm. Fall plowing has often been recommended, but it is doubtful if this measure is effective. The insects breed with such rapidity during the summer that any benefit of fall plowing is overcome. Some benefit has been obtained by dusting sweet corn, during the silking period, with pow-

dered lead arsenate, but this is not practical except with sweet corn, and even then the arsenical can be safely used only when the husk completely covers the tip of the ear. Varieties that have long, tight-fitting husks are protected to a certain degree from the work of this worm. Late-planted corn seems to be more susceptible to ear-worm damage than early-planted corn.

The ear-worm should not be confused with the recently introduced European corn borer, which is described later.

American stalk borers.—There are several kinds of stalk borers. The chief importance of these insects is the possibility of confusing them with the much-feared European corn borer described further on.

One stalk borer commonly found in the Corn Belt has broader, darker brown stripes than the pale stripes of the European borer. It does its work early in the season, whereas the European borer is most active after tasseling time. The American stalk borer does little damage and its control is not important.

Insects that Work on the Entire Plant

European corn borer.—The adult is a moth which flies from place to place during late June and early July and deposits eggs on corn leaves of plants 2 or 3 feet high. It is not attracted by plants less than a foot high. These eggs hatch into small, smooth caterpillars which bore into the stalk. The entire plant, including tassel, stalk, and ear, is invaded. Damage does not become apparent until August.

The larvae pass the winter in the stalk. The borer is rather light in color, with a row of small, dark-brown spots on each segment, while several dark brown or pink lines extend lengthwise of the body. Because the adult is a moth, the borer is easily spread. The moths either fly or may be blown for great distances.

The borer is one of the worst pests of Hungary. It was

introduced into Massachusetts in 1917, and into southern Ontario, just across the lake from Ohio, about the same time, or perhaps a little earlier. The Ontario infestation spread about 1920 to Ohio and Michigan. Since then, the pest has spread to eastern Wisconsin and northern Indiana. Little general damage has been caused at this writing, in 1936, in either Ohio or Michigan, but the pest is spreading, and it is known from the Ontario experience that in a few more years northern Ohio corn growers will be suffering severe damage unless they are willing to co-operate in plowing all cornstalk

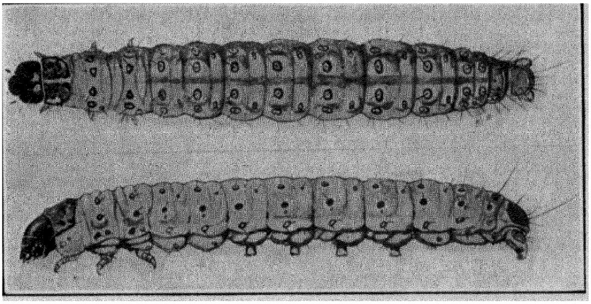


FIG. 49.—European corn borer (*greatly enlarged*). The full-grown caterpillar is about one inch long.

ground in such a way as to turn under all stalks and other vegetable matter. That this can be done practically has been demonstrated beyond all doubt. Ideal equipment is an 18-inch plow equipped with running coulter, jointer, and three wires attached to the axle of the plow. It is not necessary to plow more than 6 inches deep with such equipment because the big object is to leave nothing on the surface under which the borers can hide. It makes no difference if the borers come to the surface if they have nothing to hide under because they perish quickly when unprotected. The plowing can be done any time previous to the middle of May.

During the early years of its invasion the borer causes very

little damage. In fact, it is necessary to have three or more borers in a stalk before the damage becomes serious. For this reason it is easy for farmers to become skeptical about the seriousness of the borer during the first five years of the infestation. Some entomologists say that in the drier climate west of the Mississippi the borer may not thrive nearly as well as in the cooler, moister climate of New England and northern Ohio. Excellent information on the European corn borer is contained in various state agricultural experiment station bulletins and Farmers' Bulletin 1548 of the United States Department of Agriculture at Washington. Sooner or later, the pest is certain to reach the center of the Corn Belt, but its progress can be much delayed if the state and federal authorities keep continually on the job and are able to get the whole-hearted cooperation of the farmers in infested districts.

The European corn borer has possibilities of causing as much damage to the corn crop as the boll weevil has caused to the cotton crop. There is grave danger that it will reach the heart of the Corn Belt soon.

Insects that Work on Stored Corn

There are several insects of stored corn, only a few of which are mentioned in this chapter. On account of the severe winters, they ordinarily do not damage corn greatly in a large part of the Corn Belt, especially the northern section, but they are highly injurious in the humid south.

The rice weevil and the angoumois grain moth are two insect pests of stored corn that are often found in large numbers where the storage temperature is above freezing during the winter. The weevil is injurious to the stored grain of many crops. The small reddish-brown adult beetle drills a tiny hole in the kernel and inserts its egg. The white larva or grub spends its entire life inside and eats the kernel. Several may be found in one kernel. The pupal stage is white and transparent. The angoumois grain moth is not abundant in the Corn Belt, but

is a serious pest in the south. The small round emergence holes in a kernel of corn are characteristic indications of attack by this insect. The moths are buff in color. The larva which feeds within the kernel is a small, whitish worm.

Under farm conditions, the most practical form of control is fumigation with carbon disulphide. The fumes of carbon disulphide are heavier than air, hence the liquid should be applied to the surface of the corn to be fumigated. The average dosage used is from 1 to 2 pounds for 100 bushels of grain in a reasonably gas-tight container or bin. Corn contained in loosely built bins or open cribs cannot be very successfully fumigated with carbon disulphide or any other fumigant. Since the gas is highly inflammable fire in any form should be kept away from the building in which it is being used. The fumes are also somewhat poisonous and should not be breathed in concentrated form.

In grain elevators carbon disulphide alone cannot be used on account of its inflammability. Instead chloropicrin, calcium cyanide, mixtures of carbon disulphide with carbon tetrachloride, and mixtures of ethylene dichloride with carbon tetrachloride are used.

Other pests.—Birds, like the blackbird and crow, eat a large amount of the planted seed, and sometimes part of the crop. Rodents and rabbits often cause a reduced stand by eating the seed. Some farmers attempt to poison these pests. Others spread a bushel or so of well-soaked corn around the edges of the newly planted field of corn. The pests feed on this soaked corn and do not disturb the planted seed.

DISEASES OF CORN

Corn is freer from disease damage than most other crops. The two important groups of diseases of corn are corn smut, with which every corn grower is familiar, and the rots (*Fusarium, Diplodia,* etc.). Previous to 1913, much of the damage caused by the latter group of diseases was attributed to the

corn root-worm, the corn root-louse, or to drouth. There are possibly ten different bacterial or fungus organisms which play some part in root or ear rotting, stalk stunting, leaf rolling, joint discoloration, or leaf reddening in the cornfield.

Corn Smut

All corn growers are familiar with the black balls of corn smut which are found in every cornfield. It is a typical fungus with the mycelium growing inside the stalk or leaf of the corn plant. Externally, smut first appears as a rather lustrous, lead-colored bump, but this bump swells and darkens until its bursts and lets loose the black smut spores, which are in effect the seeds which carry over the disease in the soil for another year. In the average field, smut causes the loss of one-half to one bushel an acre, but in many fields it causes the loss of two or three bushels an acre. The accompanying map (Figure 50), based on information compiled by the U. S. Department of Agriculture, indicates that smut is a much more serious matter on the extreme southwestern edge of the Corn Belt than it is in the central part. Possibly extreme drought and heat are favorable to the development of corn smut.

No one has discovered any effective way of preventing corn smut. Rotation helps somewhat. After corn has been grown on the same field for more than two years, the infection seems to become worse. Theoretically, it should help to go over the field several times in July and August and pick off the smut balls before they burst, but this is absolutely impracticable. Treating the seed with formaldehyde, in the same way as small grain is treated for smut, does not reduce the percentage of smut. The one practical method of attack is to breed for strains of corn which are smut resistant. At the Minnesota and West Virginia experiment stations it has been proved that some strains of corn are completely immune to smut on badly infested land where other strains have 30 per cent or more of the stalks

infested. It would seem to be worth while to avoid picking seed ears from stalks which show even the slightest signs of smut infection. The constructive corn breeders of the future will do some of their best work in developing high-yielding strains of corn which are much more resistant to smut than any we now have.

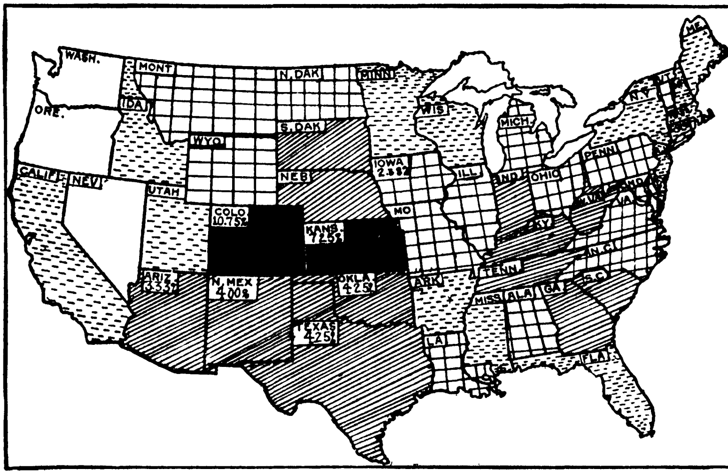


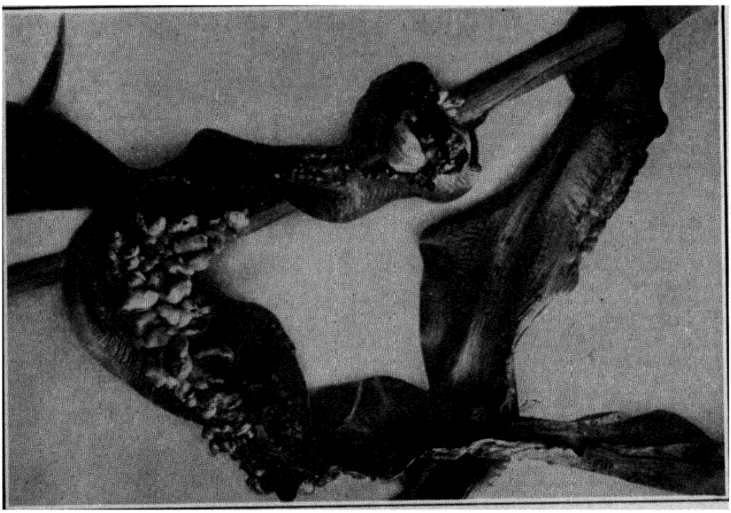
FIG. 50.—Estimated percentage of corn crop destroyed by smut. Solid, over 5 per cent. Diagonal lines, 2.6 to 5 per cent. Squares, 1.1 to 2.5 per cent. All others under 1.1 per cent.

Corn smut is not poisonous. It has been fed in large quantities to livestock without bad effects. In fact, an eastern experiment station states that it makes an excellent substitute for mushrooms, for human consumption, if gathered before reaching the bursting stage.

In the Corn Belt and most other corn-growing sections smut is caused by *Ustilago zeae*. In Washington and Oregon, however, smut in corn is caused by another fungus, *Sorosporium reilianum*, or head smut of sorghum.

Rots

The large group of diseases classed under the name of rots is known to be caused by one or more species of the following fungi: *Diplodia, Fusarium, Rhizopus, Mucor, Verticillium, Penicillium, Aspergillus,* and *Gibberella.* Bacteria are responsible for some of the rots.



Courtesy of Iowa Station.

FIG. 51.—Corn smut.

Probably the most clear-cut and outstanding of the rot diseases of corn is *Diplodia,* which infects the entire plant but manifests itself most noticeably in the form of moldy ears—ears which are moldy altogether apart from any mold following damage by the corn ear-worm. White streaks of mold found between the kernel tips are signs of *Diplodia.* In bad attacks, the entire ear will be a mass of white mold. Many apparently good seed ears are slightly infected with *Diplodia,* and when planted produce a very high percentage of stunted and barren stalks. One of the most important things to look out for when

shelling the seed ears by hand is to throw out any which show the slightest trace of mold at the kernel tips. *Diplodia* is doubtless carried over from one year to the next in the soil as well as in the seed corn, but apparently nothing can be done about the presence of the disease in the soil. *Diplodia* does not do so very much damage if strong, mold-free seed is planted, provided the late summer and early fall are not unusually moist and warm. In 1922, Holbert, of the United States Department of Agriculture, began treating seed corn with different substances to prevent *Diplodia* damage. After five years of work, it seemed that organic mercury dusts were most effective in increasing the germination and vigor of seed which was infected with Diplodia. The treatment was to dust the seed corn with a tablespoonful of the dust to a peck of corn or 2 ounces to the bushel. Circular 34 of the United States Department of Agriculture gives a quite complete account of the method of treatment, etc. Though there is much variation, it seems that the yielding power of ordinary seed corn is usually increased a bushel per acre and of diseased seed 5 or 10 bushels per acre. Inasmuch as the cost of this dust treatment per acre is only 5 cents it seems worth while. In the western part of the Corn Belt it seems to be less worth while than in the eastern part.

Many species of *Fusarium* attack a great variety of plants. Ordinarily, they are not so very serious. One of them, when weather conditions are just right, causes scab in wheat. It has been definitely demonstrated that the same *Fusarium* (*Gibberella* s. is a type of *Fusarium*) may, when corn is following wheat, cause very serious damage to corn. Several other Fusaria infect corn, and most of them are carried over winter not only on the cornstalks but also inside the kernels of corn. No method of treating the corn with formaldehyde will free the kernels from infection. Apparently all that can be done is pick out the ears that are infected and avoid planting them. Illinois experiments indicate that seed which is infected

with *Fusarium* will yield fully 20 per cent less than disease-free seed. Iowa experiments indicate that under favorable conditions of soil and weather there is very little difference in yielding power between seed infected with *Fusarium* and seed not infected. There is no question about the low-yielding power of seed infected with *Diplodia*, but there seem to be some conditions under which some *Fusaria* are not so very serious.

One interpretation of the rots.—Hoffer, at the Indiana station, has proved that on soils lacking in phosphorus, potassium, and lime, corn plants are susceptible to absorbing iron and aluminum from the soil. Iron settles at the joints of the corn plants and clogs up the food-carrying canals of the plant. Aluminum settles in the leaves and causes a type of leaf firing. Both iron and aluminum make the plants unhealthy, and as a result they are easy victims for the rot diseases. Hoffer has proved that some strains of corn are especially good in poor soils in the matter of resisting iron and aluminum temptation; that they make a special effort to find the healthful phosphorus, potash, etc., even though the soil is exceedingly poor in these true plant foods. These strains of corn are also unusually good in resisting root rots and stalk troubles. Holbert has proved that certain strains are unusually resistant to the rot troubles, but he thinks that rot susceptibility is often linked with a liability to chilling at temperatures no lower than 45 degrees.

Controlling the rots.—From the standpoint of practical action against the rots, the first thing is to select normally matured ears from normal stalks in the field. Go over the seed ears and throw out all having kernels with starchy backs. Throw out the ears that are light for their size and show any sign of disease at the shank. Shredded, dull-colored shank attachments indicate disease. The next step is conducting the germination test with unusual care and with an eye open for signs of infection. However, the Ohio station states that

although experts can use the germination test to select disease-free ears, the average person can not make practical use of the germination test from the disease standpoint. There are two methods of testing for diseased ears. One is a table germinator with a limestone-sawdust base. The other is a modified rag doll.

Modified rag doll.—The following directions are designed to help in constructing the special form of rag doll to pick out rot-infected ears:

1. Lay a 12×60-inch strip of firm, water-finish fiber (butcher's paper) on a table.
2. On top of the paper lay a 12×54-inch moistened strip of muslin.
3. Place eight representative kernels from each ear in a row, with germ sides down and tips pointing in the same direction.
4. Roll the paper and cloth into a doll, as described in the making of the rag doll.
5. Store the dolls in a warm, moist place for seven days.
6. The stored dolls should not come in contact with one another.
7. A box with wire cross rods 3 inches apart in the upper part of the box is suitable for storage.
8. Keep the dolls moist and see that the container allows drainage.
9. Unroll the dolls and read the test.
10. The percentage of germination of each ear is determined in the usual way, and the seedlings are then examined for molding or rotting. The seedlings which have discolored or rotten stems or rots, or which come from rotten kernels, indicate ears infected with disease.

In Franklin county, Indiana, there is a large community seed-corn-testing plant in which hundreds of thousands of ears are tested with the modified rag doll. The Indiana farmers who send in their seed ears to this plant are given back the corn which has been proved by the testing plant to be of high germinating power and free from disease. In Indiana and Illinois it is believed that such corn will yield fully 10 bushels more per acre than ordinary seed corn. On the richer soils of Iowa and Nebraska there does not seem to be so much advantage in favor of the corn which has been proved to be free from disease.

At the Nebraska station, it was found that the important thing was to pick horny, smooth kernels. This type resists disease better than the rough, starchy sort, but under Nebraska conditions the horny, smooth type seems to have a merit altogether apart from disease resistance.

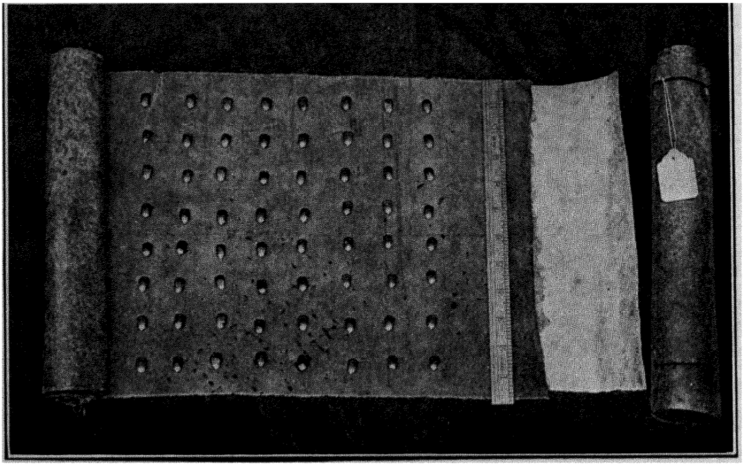


FIG. 52.—Placing eight kernels from each ear in the modified rag doll.

Disease-resistant corn.—Holbert and Hoffer have proved that some inbred strains are remarkably resistant to rot troubles. Moreover, when these unusually resistant inbred strains are crossed, they produce very high yields and the stalks stand up strong and straight. It would seem, therefore, that the most constructive work in controlling root rot diseases will be done by the plant breeder who brings about productive combinations of strains which are resistant to disease.

Effect of soil.—Soils rich in phosphorus, potash, and lime, which have been under a rotation with clover once every four years and with corn not often than two years in succession, are not bothered seriously with the rot diseases. Poor soils are greatly benefited by an application of 2 tons of limestone and

200 pounds of acid phosphate per acre, together with clover in the rotation. Treatment of this sort seems to be especially necessary on the tight clay soils of Indiana if serious rot trouble is to be avoided. On a few soils in the eastern and southern part of the Corn Belt it is necessary to apply potash although usually lime, phosphate, clover, and manure will take care of the rot troubles.

Conclusion.—In the present state of our knowledge, the practical way of handling these diseases is to apply lime to acid soils, grow clover once in four years, avoid growing corn on the same land more than two years in succession, burn the cornstalks, avoid following scabby wheat with corn, and plant seed corn which the germinator indicates to be disease-free.

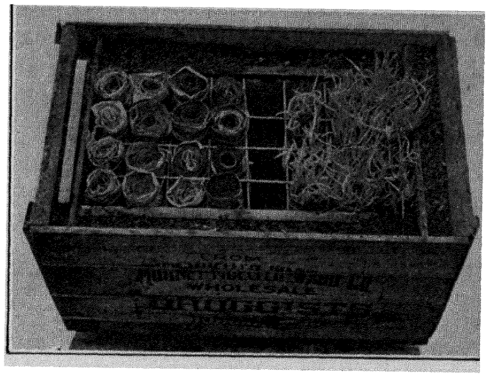


FIG. 53.—Keeping the modified rag doll moist.

Either the experiment stations or the seed companies should develop special high-yielding strains of corn that are resistant to the entire group of rot diseases and smut and other corn diseases as well.

Other diseases.—Corn rust is a common disease of the plant. This disease affects mainly the leaves and tassel of the plant, and interferes with their functioning. However, the damage is not great, and little attention has been given to control measures. Other diseases of corn are sheath spot, wilt, and damping-off.

SELECTED LIST OF REFERENCES

WALTON, W. R. The True Army Worm and Its Control. U. S. D. A. Farmers' Bul. 731. Rev., 1922.

DAVIS, J. J. The Corn-Root Aphis and Methods of Controlling It. U. S. D. A. Farmers' Bul. 891. 1917.

LUGINBILL, P., and AINSLIE, G. G. The Lesser Corn Stalk-Borer. U. S. D. A. Farmers' Bul. 539. 1917.

AINSLIE, G. G. Webworms Injurious to Cereal and Forage Crops and Their Control. U. S. D. A. Farmers' Bul. 1258. 1922.

LUGINBILL, P. The Southern Corn Rootworm and Farm Practices to Control It. U. S. D. A. Farmers' Bul. 950. Rev. 1922.

WALTON, W. R. Cutworms and Their Control in Corn and Other Cereal Crops. U. S. D. A. Farmers' Bul. 739. Rev., 1933.

HOLBERT, J. R., BURLISON, W. L., KOEHLER, B., WOODWORTH, C. M., and DUNGAN, G. H. Corn Root, Stalk and Ear Rot Diseases and Their Control Through Seed Selection and Breeding. Ill. Bul. 255. 1924.

POTTER, A. A., and MELCHERS, L. E. Study of the Life History and Ecological Relations of the Smut of Maize. Jour. Ag. Res. Vol. XXX. Pp. 161-73. 1925.

CAFFREY, D. J., and WORTHLEY, L. H. The European Corn Borer: Its Present Status and Methods of Control. U. S. D. A. Farmers' Bul. 1548. Rev., 1935.

LUGINBILL, P. The Fall Army Worm. U. S. D. A. Tech. Bul. 34. 1928.

DAVIS, J. J. Common White Grubs. U. S. D. A. Farmers' Bul. 940. Rev. 1929.

BACK, E. A., and COTTON, R. T. Control of Insect Pests in Stored Grain. U. S. D. A. Farmers' Bul. 1483. 1931.

PHILLIPS, W. J., and BARBER, G. W. The Corn Earworm as an Enemy of Field Corn in the Eastern States. U. S. D. A. Farmers' Bul. 1651. Rev., 1935.

PARKER, J. R., WALTON, W. R., and SHOTWELL, R. L. How to Control Grasshoppers in Cereal and Forage Crops. U. S. D. A. Farmers' Bul. 1691. 1932.

SATTERTHWAIT, A. F. How to Control Billbugs Destructive to Cereal and Forage Crops. U. S. D. A. Farmers' Bul. 1003. Rev., 1932.

AINSLIE, G. G. The Larger Corn Stalk-Borer. U. S. D. A. Farmers' Bul. 1025. Rev., 1933.

FLINT, W. P., and LARRIMER, W. H. The Chinch Bug and How to Fight It. U. S. D. A. Farmers' Bul. 1498. Rev., 1934.

WALTON, W. R. How to Detect Outbreaks of Insects and Save the Grain Crops. U. S. D. A. Farmers' Bul. 835. Rev., 1935.

PARKER, J. R. Fight Grasshoppers by Plowing Stubble. U. S. D. A. Cir. 302. 4 pp., illus. Sept., 1933.

REED, C. O., GRAY, R. B., WORTHLEY, L. H., and Caffrey, D. J. Fighting the Corn Borer with Machinery in the Two Generation Area. U. S. D. A. Cir. 132. 50 pp., illus. Aug. 1930.

CHAPTER X

RAISING CORN FOR FODDER AND SILAGE

CORN fodder is the source of a large amount of feed for all types of livestock. The entire plant, including ears, is referred to as corn fodder, while the stalks without ears are called corn stover. This chapter will deal with both corn fodder and stover, and also the method of handling corn for silage.

Choosing the varieties for fodder and silage.—In the present state of our knowledge, the safe thing for most Corn Belt farmers to do is to stick by the regulation grain sorts as commonly grown in the community, since the grain is the most valuable part of the plant. Approximately 60 per cent of the digestible food materials present in the corn plant are found in the ears, and 40 per cent in the stover. Eventually we shall do as in New York and New England, where almost invariably a different variety is used for fodder than is used for grain. Our present varieties are not perfect. They blow down too easily. A two-eared sort of Reid or Leaming might be well worth while for fodder and silage and a little later sort may better be used for fodder than for grain.

The large, late-maturing varieties from the southern states have in some cases given a larger amount of dry matter than the adapted local varieties, but as the difference is relatively slight and the quality of fodder and silage relatively poor, and a much greater tonnage of green fodder must be handled, owing to the greater percentage of water in the more immature southern varieties, those adapted to the locality are considered more profitable.

It is desirable to plant corn which is to be used for fodder or

silage just as early as if the crop were to be harvested for grain only. The corn should mature early enough to be ready to harvest before frost, as only in that way is the maximum yield

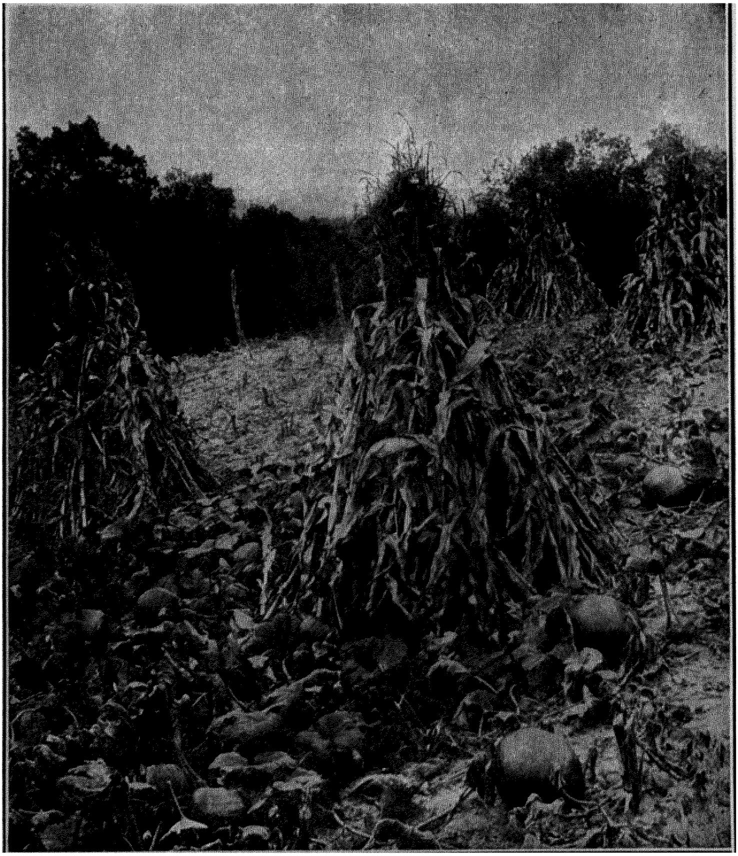


FIG. 54.—Shocks should be large, containing forty bundles.

of dry matter obtained. In some instances, when it has been found necessary to plant a field of corn rather late in the season, it has been found desirable to use the replanted corn for fodder,

as the crop will often become sufficiently mature before frost to make a fair quality of fodder or silage when it would not do to crib.

Planting for Fodder or Silage

It really makes little difference whether corn for fodder or silage is drilled or checked. If the land used is very weedy, checking undoubtedly will be the safest method, as the weeds can be better kept under control by cultivating in both directions. On clean ground, drilling is often preferred, as the plants will be more uniform in size and the corn binder will run more smoothly, since the stalks are cut one at a time. On very fertile, clean ground, a somewhat greater yield may be secured by drilling.

Rate of planting.—Corn for fodder or silage may be planted a little thicker than for grain, as a greater yield of both grain and fodder usually will result. The rows are placed $3\frac{1}{2}$ feet apart and the kernels dropped so that there will be one stalk every 9 or 12 inches in the row when drilled or three to five stalks per hill when checked. The thickness of planting should depend somewhat upon the fertility of the soil, the variety of the corn, the amount of rainfall in the region and to some extent upon the length of the growing season. If the corn is planted too far apart, the stalks grow rank and woody, there is a tendency to mature late, and also the yield will be reduced. On the other hand, if the corn is planted very thick, the percentage of grain will be reduced. Table XII, Chapter VI, giving the results with different rates of planting at the Ohio station, indicates that on fairly rich land in the north-central part of the Corn Belt it pays to plant somewhat thicker for both fodder and silage than most farmers have been in the habit of planting. Generally speaking, corn for fodder or silage should be planted about 40 per cent thicker than for grain. Probably the greatest drawback from thick planting is the increased tendency for the corn to blow down.

Harvesting

Time to cut.—The best results are obtained by cutting when the kernels are well dented and hard and the lower leaves of the plant turned brown. At this stage, the corn plant has its greatest feeding value. In addition, it is in good condition to put into the silo.

Although there is some difference of opinion as to the best time to harvest corn for silage, it is generally conceded that immature corn does not make the best quality of silage. When corn is cut too early, the silage has a dark color, contains too much acid and some of the feeding value is lost. Some farmers prefer greener silage for feeding to dairy cows than for feeding to beef animals. For the value of corn at different stages of growth, see Table IX, Chapter III.

Of course, it is desirable not to allow the corn to become fully ripe because the plants become more woody and leaves are lost. If, however, the corn becomes over-ripe before cutting, a good quality of silage can be made if a little water is added by running it into the top of the blower with a hose while the silo is being filled. Sufficient water should be added to make it possible to pack the silage firmly.

Method of harvest.—Corn for fodder or silage may be cut by hand, with a sled or platform cutter, or with a binder. Cutting by hand is slow work, requiring fully three times as much man labor as with a corn binder. Hand cutting is almost never used in the Corn Belt except when the corn is badly down. The sled or platform cutter requiring two men to operate is a cheap machine which does not get out of order. However, the two men find the work much harder than the single man who drives the corn binder. The corn binder, because it is faster and easier on the men, is almost universally used in the Corn Belt, in spite of the fact that it is a rather expensive machine which gets out of repair rather easily. In using the corn binder, it is well to make the bundles rather small if the corn is to be put into the silo, because small bundles make loading easier and enable the

corn to run through the silage cutter more smoothly. Usually three horses are used on a corn binder, although occasionally four are put on.

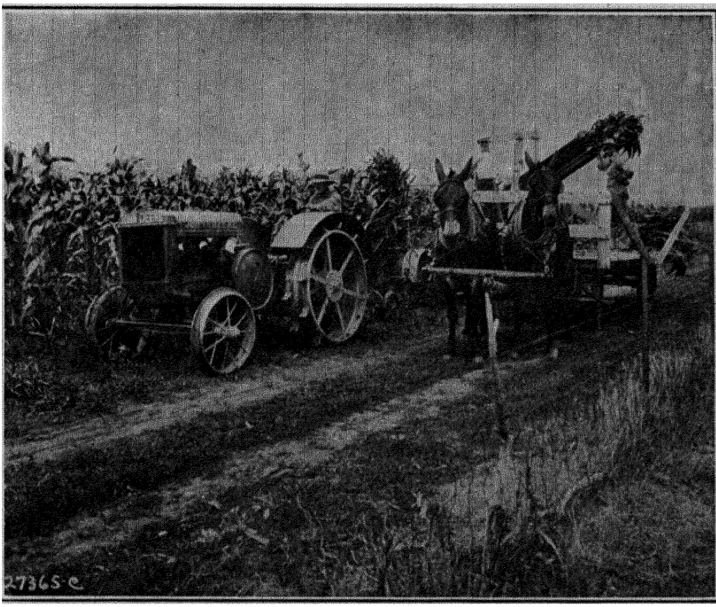


FIG. 55.—Binding corn and elevating the bundles with an attachment to the corn binder.

TREATMENT AND USE OF FODDER AND STOVER

Shocking corn fodder.—Ripe corn should be shocked as soon as it is cut. If the corn is green and full of moisture, it should be allowed to lie on the ground for a few days. The shocks should be large, containing about forty medium-sized bundles. Two men working together can build a firm shock by setting the bundles in an upright position, the butts firmly on the ground, and bracing the shock from all sides. The tops of the bundles may be closely compressed together with a small rope that has a

ring in one end. Binder twine may then be used to hold the tops together and the rope released for use on the next shock. A shock of this type should stand a year with a minimum amount of waste.

A practical farmer reports that he has had good results in building shocks by setting several bundles horizontal and crosswise of each other with the ears of the bottom bundles on the stubs of a hill of corn. He then fits the upright bundles in around these crossed horizontal bundles and has a shock which will stand up stiff and straight.

Losses in corn fodder.—There is a loss of feed value in both silage and fodder. However, the loss in the latter is greater. No matter how well shocked, corn fodder will lose in value. Corn fodder or stover standing in the field for a few months, according to Henry and Morrison, loses 20 per cent of the dry matter it contains, due to weathering and fermentation. They say that the losses are in the sugar, protein and starch, the most valuable parts.

Utilization of fodder.—Corn fodder may be utilized in any of the following ways:

1. Soiling crop—cut green and fed.
2. Dry corn fodder—cured in the shock.
3. Shredding—ears removed and stover torn in small pieces.
4. Stover—ears removed and stover fed.
5. Silage.
6. Miscellaneous uses.

Corn as a soiling crop.—Because of poor pastures in the late summer, many farmers feed green corn to their livestock. Usually the corn is cut daily and fed. This corn is palatable and relished by all kinds of livestock. More corn is used this way than is generally realized. Sweet corn and early varieties of dent corn may be used to good advantage, for they are ready to feed early in the season.

Dry corn fodder.—The cured corn fodder (shock corn) may be fed directly from the shocks or from stacks where it is stored for ease in feeding. Fodder should not be put in stacks or mows

until it is cured. The stacks should be narrow and not over 10 feet high, and it may be advisable to put layers of straw or hay between the layers of fodder bundles. There is some waste in both corn and stover in feeding fodder. It is not nearly so valuable as silage. Corn may be thickly grown and cured to make a coarse hay.

Shredding.—Most of the shredding machines now used husk the ears from the fodder and then tear the stover into small

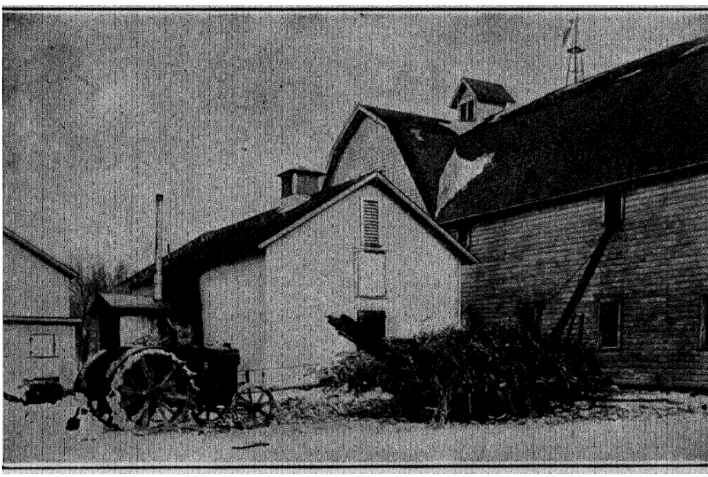


FIG. 56.—Shredding corn fodder.

strips. The husked ears are elevated into a wagon and the shredded stover is elevated or blown into the barn or stack. The shredded stover is easily handled, and there is less waste than in ordinary stover. The shredded stover makes good bedding. Large piles of shredded stover heat easily, especially if the stover is green. The addition of salt helps to keep down heating. Usually, shredding is done late in the season. The customary charge for shredding is usually around $4 an acre. The practice is most popular in the eastern and northern sections of the Corn Belt.

Corn stover.—Often the ears are removed from shock corn and the stover fed directly to livestock as a roughage. The stover of small, early varieties as grown in the northern Corn Belt is of good quality. Stover may be fed to all classes of livestock and will " carry over the winter " cattle and idle horses.

Miscellaneous practices.—In some sections, especially in new regions where machinery is scarce, corn fodder is run through an ordinary threshing machine. The grain is shelled and the stover blown into the barn or stack. In the south, corn is topped—stalk cut off just above the ear—and the leaves are stripped from the stalk for feed. This practice is often followed to hasten maturity. However, the practice is not recommended, for it reduces the yield of ear corn very greatly.

There is a special machine for making stover silage. The corn fodder in this case is run through the machine and the ears are husked and cribbed and the stover is put into the silo.

Standard day's work.—Under favorable conditions, the following number of acres can be handled in a ten-hour day:

Cutting:

Binder, 40-bushel corn, one man, three horses	8.0
Platform cutter, 40-bushel corn, two men, two horses	6.0

Shocking and cutting by hand:

After binder, two men	3.6
Cut and shock by hand, one man	1.4

CORN SILAGE

Why corn should be put into the silo.—Silage aids the farmer to utilize fully the food value of the crop which he produces. Corn properly stored in the silo saves more of the food value of the plant than is possible by any other method. Not only is there a saving in food value, but the crop may then be fed practically without waste. Silage is very palatable and is readily eaten by almost all classes of farm animals, being espe-

cially well suited for cattle and sheep. Silage furnishes a succulent feed in winter when greatly needed and is also a valuable supplement in late summer and early fall when pastures are likely to be short. When corn is harvested as silage, the farmer is less dependent upon the weather, and the crop is stored in a smaller space and more convenient form for feed than it is possible to store the same amount of corn as dry fodder.

The use of silage crops dates back to the time of Caesar. The Romans stored green feeds for their horses in the ground. The Germans made use of silage for animal feed many centuries ago. However, silos have been in use in the United States only during the last half century. Since their introduction, the number has increased rapidly, until the " watch towers of prosperity," as they are called, dot the entire Corn Belt and the great dairy states.

There are about half a million silos in the United States, of which about one-third are found in the dairy sections of Wisconsin, New York, Minnesota and New England. In the dairy sections, silos are found on every third or fourth farm, whereas, in the Corn Belt proper, silos are found on about one farm in ten.

Selecting the kind of silo.—There are many kinds of silos in use to-day, but there are only two general types:

1. Pit silos—built partially or wholly below ground.
2. Above-ground silos—built of wood or masonry.

The first type is found only in the western edge of the Corn Belt and the plains section. The second type includes nearly all the silos of the Corn Belt. No attempt will be made to describe the building of either type. But the desirable features of a well-built silo may be stated as follows:

1. The walls should be as air-tight as possible.
2. The walls should be strong enough to resist the pressure of the silage.
3. The inner surface of the wall should be smooth.
4. The location and construction of the silo should prevent freezing.
5. It should be built to resist high winds.
6. It should be cylindrical in shape and have plenty of depth.
7. It should be convenient for filling and emptying.

8. The foundation should be durable and extend below the frost line.
9. A permanent silo of neat appearance adds much to the farm.
10. The silo should be simple in construction and low in cost.

The Silage Process

Silage is finely chopped green material packed in an air-tight receptacle. All reference, unless otherwise noted, will be to corn silage, for it is the common silage used. The making of silage is a fermentation process, which begins as soon as the silo is filled. The following changes are brought about:

1. Increase in temperature—85 to 90° F.
2. Evolution of carbonic acid gas—dangerous in pit silos.
3. Change in color—darker.
4. Aromatic odor—desirable.
5. Formation of acids—1 to 2 per cent of weight.
   (*a*) Lactic acid—acid of sour milk.
   (*b*) Acetic acid—acid of vinegar.
6. Formation of alcohols—1 to 4 per cent of weight.
7. Breaking down of proteins—no loss to silage.

These changes, which are bacterial, physical and chemical, are practically completed at the end of two weeks, and the silage is made. Silage may be kept for years in a tight silo without loss of palatability or value. It is important, however, that the silage be well packed and the silo very tight, because air permits the development of molds, which are sometimes poisonous and which quickly destroy the acids and thus allow the silage to spoil. Bacteria which cause decay will not live and work in the presence of lactic and acetic acids when no air is present.

Common yields of silage.—Under average conditions, a 50-bushel crop of corn will produce eight or nine tons of silage per acre. With the varieties as ordinarily grown in the Corn Belt, and with the customary rates of planting, silage normally runs about 6 bushels to the ton, which indicates that as a rule a 42-bushel yield of corn means a 7-ton yield of silage. With the rank-growing southern varieties of corn there may be only three or four bushels of corn per ton, whereas with some strains

of Reid there may be as high as seven or eight bushels of corn per ton of silage.

Hauling to the silo.—Most of the corn fodder for the silo is hauled on ordinary racks. A low-down rack has some advantages in loading. The general custom is to have about seven wagons hauling, with an extra man at the cutter to help unload. Bundles are laid flat on the rack, with butts one way. Usually the bundles are hauled as soon as the corn is cut. As a rule, two men are used in the field to hand up bundles to the man on the wagon. One of these men may be eliminated, however, and considerable hard work dispensed with if the corn binder is equipped with a bundle elevator so that the wagon can be driven alongside the binder as it cuts. The objection to this plan is that if anything goes wrong with the binder, there is no corn cut ahead and the whole crew is laid up until the binder is repaired.

Filling the Silo

The man who feeds the corn to the ensilage cutter affects very directly the progress which is made. He determines the length of the pieces into which the silage is cut. An important precaution is to see that the knives of the cutter are sharp at all times. Two or three sets of knives are maintained for most cutters, so that they may be changed or re-sharpened once or twice a day.

Adequate power to drive the cutter is another prerequisite to efficient silo-filling, whether the source of power is a gas tractor or a steam engine. A large cutter and a small engine will slow up the operations. Reserve power is highly important if the cutter is to run smoothly and do the best work. In Missouri Bulletin No. 226 it is stated that, "The maximum capacity of a silage cutter in tons per hour is about the same as the width of the throat in inches; and the horse power required is from one to one and a half times the capacity in tons per hour."

Stake the cutter down firmly in a place where the teams can

get to it easily, and where the blower pipe can be placed as nearly as possible straight up and down. Line the engine up with the cutter so that the belt runs smoothly. The rule for size of pulleys on engine and cutter is: Multiply diameter of engine pulley in inches by its speed in revolutions per minute and divide

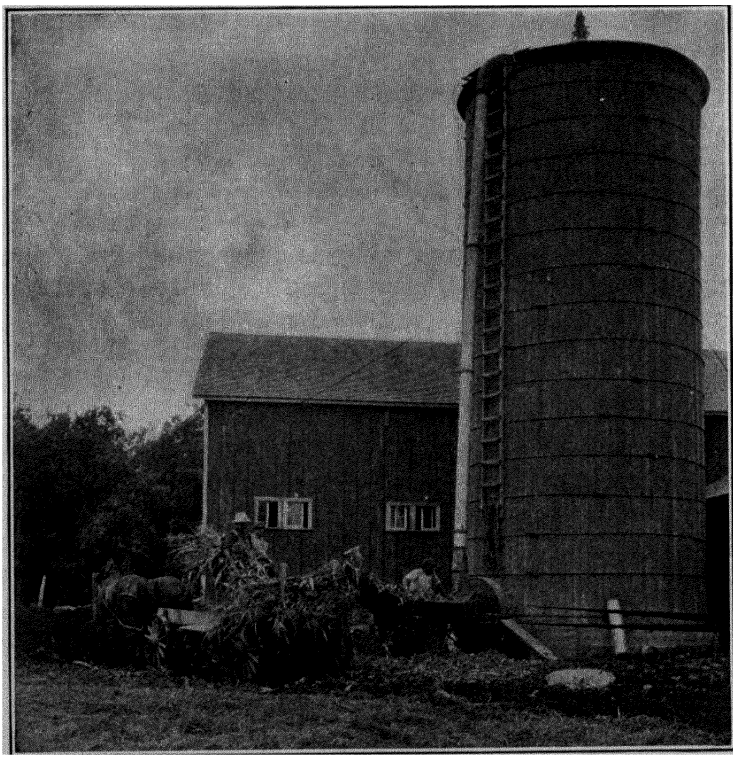


FIG. 57.—Low down racks save labor at silo-filling time.

by the revolutions per minute the silage cutter is supposed to run. The answer is the proper diameter of the cutter pulley in inches.

Much difference of opinion exists regarding the length to cut corn for silage. Some farmers prefer one and one-half inches,

while others advocate cutting not over one-half inch. The longer cuts are more economical of power and the silo may be filled more rapidly, but the silage will not pack as closely in the silo. Therefore it may not keep as well, and in addition there is more waste in feeding. All things considered, the one-half inch or three-quarter inch cut is probably the most desirable, as it packs readily and feeds out with but little waste.

Distribute and pack well.—The heavy and light portions of the finely cut corn must be uniformly distributed. The heavy part of ears and stalks should not be in the center or on one side, and the lighter part, such as leaves, on the other side, as settling will be uneven and much spoiled silage will result. In order that the full capacity of the silo may be utilized, and at the same time insure a good quality of silage, it is essential to distribute the cut corn uniformly and firmly tramp all parts of the silo, especially the outer edge. The work of distributing the cut corn and packing it is greatly facilitated by the ordinary distributor.

When a large quantity of corn is placed in a silo within a short time, a considerable settling of the silage results, making it necessary to refill the silo within a few days in order to utilize its full capacity. Where two silos have been built side by side, filling one for a day, and then filling the other for a day until the two silos are filled, partially overcomes the difficulty from settling.

Adding water.—If corn is cut at the proper time, good silage can be made without adding water. Corn in the silo at filling time should feel moist. Briefly, water should be added to corn when filling the silo under the following conditions: First, when corn is too ripe and does not pack well in the silo; second, when refilling the silo in the late fall or winter with dry shocked corn.

Preventing waste on top.—Unless feeding is commenced as soon as the silo is filled, some corn at the top of the silo will spoil. This waste may be partly eliminated in several ways. First, level off the surface and tramp firmly. Some farmers

use finely cut straw or chaff from the straw stack thoroughly packed and wet down, to cover the top. Others soak the top with water and sow oats. The oats sprout and make a thick covering which keeps out the air and reduces the waste. Satisfactory results have come from the use of tar paper spread over the surface and covered with a thin layer of cut corn from which the ears have been removed. In any case, it is a good plan to pull the ears off the last load of corn which is put into the silo.

Opening the silo.—Corn may be fed as soon as the silo is filled, but for the first few days, it is nothing but green corn finely cut. When handled in this way, there is no waste on the top of the silo. During the first ten days or two weeks, fermentation takes place, and the corn is gradually changed to silage. When silage has been allowed to stand for a time before using; the spoiled layer should be thrown away.

Refilling the silo.—After the contents of the silo have been fed out, the silo may be refilled with dry shocked fodder, if it is available. Dry corn put into the silo makes a very satisfactory feed, but it is not as high in value as silage from corn put in at the proper stage. In refilling a silo with dry corn fodder, about 250 gallons, or one ton, of water should be added to each ton of dry fodder. The water may be run into the top of the blower with a hose. It is not desirable to allow the water to run in one place, as it will follow channels and leave parts of the silage practically dry, resulting in much spoiled feed. Corn stover may be used in the above way but its feeding value is much lower than silage made from fodder. These types of silage should be made not later than February 1.

Problems of Silage

Frosted corn silage.—If the corn which is to be used for silage is frosted while still quite immature, it is best to cut it soon after frost, to avoid loss of leaves and allow the corn to cure out to some extent before putting it into the silo. In 1915, when

much immature corn was harvested for silage, many farmers cut their frosted corn, cured it in the shock, and filled their silos later in the season, adding water to facilitate the packing of the silage. Some of the farmers who put this kind of corn into the silo immediately found that the silage produced was very watery. Soft corn silage is discussed in Chapter III.

Corn silage versus other silage.—As far as its content of protein and sugar is concerned, the corn plant furnishes the most nearly ideal single plant material for silage. Plants similar to the legumes contain too much protein material in proportion to the sugar content. Sunflowers give a large tonnage, but a coarser silage. Dairy sections in the southern Corn Belt infested with the chinch bug have grown sunflowers for silage with only fair results.

Legumes, especially soy beans, have been mixed with corn for silage. Ordinary corn and soy-bean silage, resulting from growing the two crops together in the same field, usually has ten parts of green corn to one part of soy beans. The Indiana experiments indicate that the advantage of corn and soy-bean silage is more theoretical than actual. Apparently, any slight increase in the value of the silage per ton, or in the yield of the mixture per acre, is counterbalanced by the cost of the soy-bean seed and by the extra bother involved in handling the mixture.

Characteristics of good silage.—In buying, feeding or judging silage, it is well to know the characteristics of good silage. Good silage should have the following characteristics:

1. Cut in half-inch lengths (not long shreds).
2. Very leafy with few coarse stalks.
3. A large amount of grain in the stover.
4. Sweet and free from all molds.
5. Sharp odors of acid.
6. No odor of spoiled butter.
7. Even distribution of moisture.
8. From 60 to 74 per cent moisture.
9. Light in color.
10. Palatable.

Feeding silage.—Silage is ordinarily fed to dairy cows at the rate of about 30 pounds per head daily, in connection with 10 pounds of clover or alfalfa hay. With beef cows, an excellent ration for carrying through the winter is an average daily of 35 pounds of silage and 4 or 5 pounds of hay, with no grain except possibly a pound of oil meal or cottonseed meal. With fattening cattle, the typical ration is 25 pounds of silage, 4 pounds of hay, and all the corn they will eat, with perhaps a little oil meal or cottonseed meal in addition. In some cases very good gains have been obtained without any grain by feeding an average daily of 50 pounds of silage, 2 pounds of alfalfa or clover hay and 2 pounds of oil meal. Silage is ordinarily fed to sheep at the rate of 2 pounds per head daily. Moldy silage is a little more likely to cause trouble with sheep than with cattle. Silage may be fed to horses at the rate of 15 pounds per head daily, but moldy silage is even more dangerous with horses than with sheep. As a general rule, it should be remembered in feeding silage that it takes about 3 pounds of silage to equal in feeding value 1 pound of hay, and that for the best results with all kinds of livestock, silage should not completely take the place of hay, although it usually pays with cattle in the central part of the Corn Belt if silage takes the place of three-fourths of the hay in the ration.

Measuring and valuing silage.—To measure silage in a circular silo, square the diameter and multiply by .7854 and then by the depth of settled silage. This gives the number of cubic feet. If not much silage has been fed out allow 40 pounds to the cubic foot. In the bottom one-third of the silo, allow 43 pounds per cubic foot. A ton of average Corn Belt silage is worth the value of 6 bushels of corn plus 300 pounds of loose hay.

SELECTED LIST OF REFERENCES

LAMB, A. R. Silage and Silage Fermentation. Iowa Bul. 168. 1916.

WOODWARD, T. E., MCNULTY, J. B., ROMMEL, G. M., SHEETS, E. W., and MARSHALL, F. R. The Making and Feeding of Silage. U. S. D. A. Farmers' Bul. 578. 1923.

PERKINS, A. E. Losses and Exchanges of Material During the Storage of Corn as Silage. Ohio Bul. 370. 1923.

HOPPER, T. H. Composition and Maturity of Corn. No. Dak. Bul. 192. 1925.

NEVENS, W. B. Types and Varieties of Corn for Silage. Ill. Bul. 391. 1933.

WIGGANS, R. G. The Relative Growth and Development of Corn Varieties of Widely Different Maturity Dates During Successive Time Intervals Throughout Their Life Cycle. Cornell Memoir 152. 1934.

CHAPTER XI

RAISING SWEET CORN

SWEET CORN is extensively grown for canning purposes in many sections of the Corn Belt, especially in Iowa and Illinois. It takes about 1000 acres of sweet corn to maintain an efficient canning factory. Sweet corn is an early cash crop, that is usually contracted for at planting time; hence, the marketing of the crop is not a problem. Sweet corn fits in well before winter wheat in the rotation, making for some sections a better combination than field corn and oats. The stalks left in the field after snapping the sweet corn are a valuable feed, worth $3 or $4 an acre. In general, sweet corn is a profitable crop for many farmers located within four miles of a canning factory.

Choosing a variety.—The ordinary dent, flint and soft corns are usually referred to as field corn, although some of these types are occasionally used as roasting ears. Kernels of sweet corn are horny, wrinkled and translucent. The high sugar content of the kernel gives this type of corn its name and particular uses. Most sweet varieties are prolific and sucker greatly. As a rule, sweet corn requires a shorter season than field corn.

Distinct varieties of sweet corn were not well developed until the end of the nineteenth century. Now there are a great number of varieties, which are usually classified as to time of maturity. The following varieties are commonly grown in the Corn Belt for canning purposes:

1. Stowell's Evergreen—medium late, most prominent canning variety.
2. Narrow Grain—An unusually deep-kerneled, narrow-grained type of Evergreen which matures quite late.
3. Country Gentleman—late, good quality; yields less, but brings

higher price than Stowell's Evergreen; canners like it because the grains are narrow.

4. Golden Bantam—very early, small, yellow, tender; a very important canning variety in northern sections.

Sweet-corn breeders are following the lead of breeders of dent corn and are utilizing the method of selection within inbred lines for the production of hybrid corn. Probably the outstanding sweet corn so far developed by this method is Golden Cross Bantam, a hybrid corn developed at the Purdue University Agricultural Experiment Station in co-operation with the United States Department of Agriculture. It is a single-cross hybrid produced by crossing two inbred strains of Golden Bantam. It is a yellow variety of rather early maturity and shows high resistance to bacterial wilt, a disease which is a limiting factor in sweet-corn production in various regions in the United States. Several seed companies are utilizing this method of producing new varieties of corn, and undoubtedly many of the popular varieties of sweet corn will be entirely replaced by new ones developed through this method. It must be remembered that these hybrid sweet corns must come each year from first-generation hybrid seed. Growers can find a good description of Golden Cross Bantam and this new method of breeding in United States Department of Agriculture Circular No. 268 published in March, 1933.

Determining the right soil and climate.—Good corn land is as important for sweet corn as for field corn. For a description of corn soils and fertilizers, see Chapter VI. Sweet corn is not as hardy as the field corns, and is more easily injured by frosts or backward spring weather. In addition, hot weather makes the corn tough. Cool seasons make a tender corn. Otherwise, the general relation of climate to sweet corn is about the same as for field corn.

Sweet corn when harvested at the canning stage does not exhaust the soil fertility as do most farm crops. It is a well-recognized fact that the processes involved in the maturing and

filling out of the seed make a heavy drain upon the fertility of the soil. Sweet corn is harvested before this stage is reached. At this stage, ears are 75 per cent water. As sold to the canning factory, the ears from an acre of sweet corn remove slightly more potash, 55 per cent as much nitrogen, and 25 per cent as much phosphorus as the ears from an acre of field corn. Since potash is not as important as nitrogen and phosphorus under Corn Belt conditions, it may be seen that sweet corn is quite easy on the land.

Selecting the seed.—According to Erwin, it is customary for the canners in the Corn Belt to "renew the seed supply, commonly from the New England States, every year or at frequent intervals. This practice seems to be based upon three assumptions: First, that sweet corn when grown continuously under Corn Belt conditions loses in sugar; second, becomes starchy, and third, tough." However, Erwin's tests show that these assumptions are not always true, and that adapted home-grown seed should be used.

Cultural methods to use.—A well-prepared seed bed similar to the one for field corn should be made for sweet corn. The crop should not be planted until after field corn, for it is not so vigorous and grows slowly in a cold, wet soil. From four to five kernels are planted in a hill. Planting operations and cultivation are just the same as for field corn.

Marketing and Canning

Harvesting and marketing methods to use.—Sweet corn is harvested much earlier than the field varieties. The harvest season is about a month in length, from the middle of August to the middle of September. Sweet corn is at its best for table use about eighteen days after the silks emerge. For canning factories, however, twenty-one days between silking and picking is about right. The ears are snapped with the husks on and delivered direct to the canning factory, and it is important that the corn be gathered at the right time. With the sweet corn crop there is no storage problem and no loss in shrinkage.

The customary yield on 40-bushel corn land is 2½ tons of snapped corn to the acre. Prices for sweet corn vary greatly from year to year. Corn Belt canneries usually pay for a ton of the snapped corn delivered to the factory a price equivalent to 14 or 17 bushels of new corn. Of course, unusual weather, causing unusually cheap or unusually high dent corn prices, may vary this ratio, but one year with another these figures are about right for Evergreen corn. Ordinarily, the gross income from field corn and sweet corn grown on similar land is about the same. The higher value of sweet corn stalks, however, and the other incidental advantages make the real income from sweet corn usually greater than from dent corn.

Canning the corn.—Practically all the work of canning is done by machinery, from the time the corn is dumped on the scales until it is loaded on cars with labels attached. The corn is first husked, then the ears pass through a silker, and from there they go to the cutter. The cobs are ejected from the building, while the kernels pass on to the mixing vat, where salt, sugar and water are added in proper proportions. The corn then is fed into cans, which are capped and cooked in steam for an hour or two. Labeling and boxing usually are not done until after the rush season, or until time for the corn to be put on the market. A ton of ordinary Evergreen sweet corn yields about 600 cans, or 25 cases. With prices as they have prevailed in recent years, the farmer receives from 11 to 14 per cent of the retail value. Studies made by the U. S. Department of Agriculture show that in 1935 the retail value of a No. 2 can of sweet corn was 12.6 cents and that the farmer got 1.4 cents for the corn, or 11 per cent. When Iowa sweet corn retails at $1.50 a dozen cans, the Iowa farmer is paid about 15 cents out of this $1.50. The grower of the sweet corn seems to be only one small factor in a highly complicated process. Cost of the cans, salt, sugar, labor and overhead are the important factors in determining the cost of canned sweet corn.

It will be noted from Table XV that Corn Belt states lead

in commercial sweet corn canning just as they do in the production of commercial field corn. Because of the rich soil and large level fields it is possible to produce sweet corn in Iowa and Illinois at a lower price per ton than it is elsewhere in the United States.

The finest-quality sweet corn is grown in the New England states, especially in Maine and New Hampshire. Early strains of Golden Bantam are grown on rather small fields which are very heavily fertilized. The cost of production is heavy, but the price per ton is also high and as a result a number of farmers in the New England states have been able to make fairly good money producing Golden Bantam sweet corn for the canneries.

The bulk of the sweet corn in the United States will doubtless continue to be produced in the Corn Belt from the larger-eared, deeper-grained sorts of the Evergreen and Country Gentleman type.

Husk pile silage.—Husk pile silage compares favorably with ordinary field corn silage. It is a valuable by-product of the canning factory, that is usually sold or given to the growers for feed. This silage is made up of husks, tips of ears, and cobs, which are high in protein and starch. The cobs are not as valuable as the husks and refuse ear tips. Husk pile silage ferments in the pile where it is dumped at the factory, and it need not be placed in a silo. The one drawback to its use is that it is rather acid. This is due to the early harvest of the ears for canning purposes.

Uses of sweet corn.—Most of the sweet corn grown on a field scale in the Corn Belt is sold to canning factories that are within hauling distance of the farms. Dried sweet corn is still used by farmers, and sweet corn on the ears in the "roasting stage" or "in the milk," is an important vegetable. A small amount is picked for table use. Although sweet corn yields less than field corn, a few farmers prefer it for hogging-down or sheeping-down. According to the Iowa station, "Sweet corn provides an early soiling crop. It may be harvested in early

TABLE XV

SWEET CORN, COMMERCIAL CROP FOR MANUFACTURE: ACREAGE, PRODUCTION, AND SEASON AVERAGE PRICE PER TON RECEIVED BY PRODUCERS, BY STATES; AVERAGE 1928–32, ANNUAL 1934 AND 1935

State	Acreage			Production			Price for Crop of—		
	Average 1928–32	1934	1935	Average 1928–32	1934	1935	Average 1928–32	1934	1935
	Acres	Acres	Acres	Short tons *	Short tons *	Short tons *	Dollars	Dollars	Dollars
Maine	11,520	11,200	14,700	38,000	40,300	50,000	21 28	14.90	16.50
New Hampshire	1,000	660	950	2,600	2,000	2,700	20 16	14.50	16.00
Vermont	1,690	1,050	1,150	4,100	2,800	3,100	15 60	10 60	11 10
New York	20,580	14,600	21,000	33,400	33,600	50,400	14.28	11 00	10.50
Pennsylvania	6,600	5,400	6,400	8,400	9,200	10,200	13 24	10 00	11.50
Ohio	26,100	21,000	26,400	45,400	39,900	55,400	9 64	7.20	8.10
Indiana	34,680	38,500	49,700	57,600	50,000	84,500	11 48	8.30	9 30
Illinois	59,860	63,700	90,000	131,700	89,200	198,000	11 28	7 50	9 00
Michigan	6,630	5,000	6,000	7,800	4,500	7,200	11 42	9 70	10.80
Wisconsin	10,860	11,900	15,200	23,900	27,400	38,000	10 30	8 00	8 00
Minnesota	43,000	47,800	66,000	101,400	81,300	151,800	9 76	6 00	7 80
Iowa	41,090	27,000	48,000	95,100	51,300	105,600	8 90	6 20	7 00
Nebraska	5,750	1,000	5,000	9,800	1,200	4,500	8 78	6 00	6 70
Delaware	3,400	2,400	2,800	6,300	6,000	7,300	11 00	9 50	10 50
Maryland	34,760	29,100	33,600	48,200	43,600	60,500	12 40	10.00	11 70
Tennessee	2,980	2,550	3,100	6,400	6,400	7,100	13 70	8 70	12 00
Other States †	3,450	4,770	9,300	7,900	9,300	18,300	12 48	10.11	10 43
Total	313,950	287,630	399,300	628,000	498,000	854,600	11 50	8 46	9 32

* Tonnage in husk

† Other States includes Colorado, Idaho, Kansas, Kentucky, Missouri, Montana, Oklahoma, Oregon, South Dakota, Virginia, Washington, and Wyoming.

Bureau of Agricultural Economics, estimates based on returns from canning establishments.

September before the field corn is sufficiently matured and at a time when green feed is usually scarce. Sweet corn silage has a very high value. The stalks are sweet, palatable, and contain less crude fiber and hence a higher percentage of digestible matter than field corn."

SELECTED LIST OF REFERENCES

ERWIN, A. T., and HABER, E. S. Sweet Corn Seed Studies. Iowa Bul. 250. 1928.

BEATTIE, J. H. Growing Sweet Corn for the Cannery. U. S. D. A. Farmers' Bul. 1634. 1930.

THOMPSON, H. C., MILLS, H. S., and WESSELS, P. H. Results of Sweet Corn Suckering Experiments on Long Island. Cornell Bul. 509. 1930.

ERWIN, A. T. Sweet Corn—Its Origin and Importance As An Indian Food Plant in the United States. Iowa State College Jour. of Sci. Vol. VIII. No. 3. Pp. 385-9. 1934.

JONES, D. F., and SINGLETON, W. R. Crossed Sweet Corn. Conn. Bul. 361. 1934.

TAPLEY, W. T., ENZIE, W. D., and VAN ESELSTINE, G. P. The Vegetables of New York—Sweet Corn. Vol. 1. Part III. N. Y. Agr. Exp. Sta. 1934.

CHAPTER XII

RAISING POPCORN

THE growing of popcorn on a field scale in the Corn Belt is a specialized and localized industry. Profit in popcorn growing depends largely on the grower's ability to produce popcorn of good quality, store his crop properly, and market it advantageously. In comparison to field corn, popcorn is more bother to raise, harder to get a stand, more difficult to keep clean, and more bother to gather and deliver. In addition, marketing difficulties and fluctuating prices make it an unprofitable crop for promiscuous planting.

Selecting the type of popcorn.—The three common types of popcorn are White Rice, Jap and Pearl. In the great popcorn district in Sac and Ida counties, Iowa, the White Rice and Jap are grown almost exclusively.

White rice.—The kernels are pointed at the crown. Ears are 7 or 8 inches long and carry twelve or fourteen rows of kernels. The stalks are usually 6 or 7 feet tall. It yields about 70 per cent as many pounds of ear corn per acre as ordinary dent corn grown on the same land. It is the outstanding popcorn of America, but the Jap is gradually replacing it to a considerable extent.

Jap.—The kernels are pointed like the White Rice, but are much narrower. The ears are only 2 or 3 inches long. They carry typically from twenty-four to thirty-six rows of grain. Kernels are deep but exceedingly narrow. The stalks are about 5 feet tall. It will yield about 70 per cent as many pounds per acre as the White Rice and about half as many pounds as ordinary dent corn on the same land. Because of the small ears, it

is difficult to husk. When huskers of dent corn are paid 4 or 5 cents a bushel (80 pounds of ear corn), it is customary to pay huskers of White Rice about 15 cents per hundred pounds of ear corn and huskers of Jap about 23 cents per hundred pounds of snapped corn.

Jap corn suckers less than most strains of White Rice, and the main tassel spike is shorter and thicker. Many of the stalks are somewhat hairy. Two or three ears per stalk are common.

Jap produces a more tender product on popping than the White Rice, and is much in demand on that account. Some call it Jap Hulless because it is so tender. It also increases

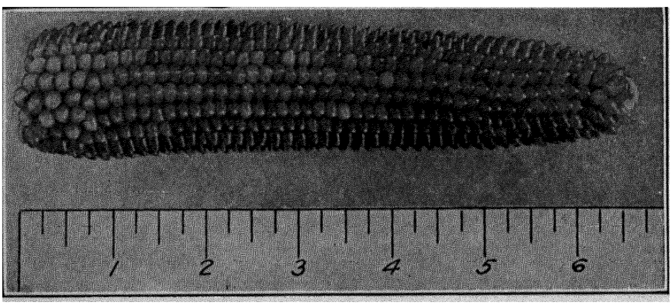


Fig. 58.—Typical ear of White Rice popcorn, which is grown commercially more than all other kinds put together.

more in bulk on popping than is the case with ordinary White Rice.

The market has normally paid from 40 to 100 per cent more for Jap popcorn per hundred pounds of snapped corn than for White Rice per hundred pounds of ear corn.

Pearl popcorn.—The kernels are rounded and shallow, and look like small flint kernels. The ears are about 8 inches long and carry eight to fourteen rows. The eating quality of Pearl popcorn is low as compared with the Jap. The large popped kernels of the eight-rowed variety are strung on strings and used as ornaments at Christmas-time. The three common Pearl varieties are White Pearl, Golden Queen, and Eight-rowed.

Some investigational work on the possibility of utilizing the new corn breeding method, selection with inbred lines for the production of hybrid corn, has been carried on by Brunson of the Kansas Agricultural Experiment Station. As yet no new hybrid varieties have been distributed to farmers, but this method of improvement offers great possibilities and there is no reason why superior varieties of popcorn should not be developed by this method in the same way as sweet and dent corns have been originated. Recently the Kansas Station developed a new open-pollinated variety, Supergold. This variety is not a hybrid but it was developed by selection based on popping tests.

Growing the crop.—Popcorn is grown in almost exactly the same way as ordinary dent corn. It should not be planted after June 1, because popcorn which is the least bit immature is worthless. An ordinary corn planter with special plates is used to plant popcorn. It may be either checked or drilled, but drilling is to be discouraged unless the land is exceptionally free from weeds. Five to six kernels are dropped in a hill, and often 3 feet 4-inch wire is used, so that the cross-rows are 40 inches apart and the planter rows 42 inches. Five to 6 pounds per acre of White Rice or 3.5 pounds of Jap Rice give a good stand.

Cultivation is practically the same as that of the dent corn. However, the smaller plant makes the first cultivation a little more difficult. Three to four cultivations are the rule, and it is "laid by" at the same time as or a little later than dent corn.

Popcorn ripens somewhat earlier than field corn, husking often beginning the last of September or the first of October. It should be fully mature before frost comes, as freezing injures the popping quality and greatly reduces its value on the market. The best quality of popcorn is obtained by allowing the ears to ripen fully on the standing stalks. Husking from the shock, though practiced in a limited way, is a very poor method. Formerly, popcorn was harvested exclusively by hand, but in late years the husking machine has come into favor as a means of

getting the corn into the crib. Both methods have their good points. Three men operating a machine will crib as much corn as five men by hand. The husking machine is discussed in Chapter II. Forty inches of White Rice per day is a good day's picking for a man. It seems to take at least twice as much labor to husk White Rice popcorn as it does dent corn.

Marketing.—From 60 to 75 per cent of the entire crop is marketed before the first of January. Some is hauled directly from the field to the market. The crop is often contracted for before the seed is put into the ground. The contract price fluctuates greatly, but is usually around $2 per hundred pounds

FIG. 59.—Popcorn cribs along railroad tracks, owned by one of the big commercial concerns in Sac County, Iowa.

of White Rice ear corn and $2.50 to $3.00 per hundred pounds of Jap rice, when prospects are for dent corn selling for 50 cents per bushel of ear corn (70 pounds) in December. Most of the popcorn cribbed on the farm is marketed shelled. Shrinkage, according to one authority, is about 30 per cent. Rat-proof cribs are often used, though rodents do less damage to popcorn than to dent corn.

Cribbing and shelling.—The Dickinson, Cracker-jack, and Shotwell people, who buy the bulk of the commercial popcorn, have built large plants for the storage of popcorn. One plant in Sac county, Iowa, consists of four cribs with a capacity of 1,250,000 pounds each of ear corn, or a combined capacity of 5,000,000 pounds, an elevator with a 350,000-pound shelled

corn capacity, and five tanks with a capacity of 2,000,000 pounds of shelled corn.

Early in the summer, shelling starts in the big cribs and is kept up intermittently all summer, so that the cribs will be empty in time for the new crop. The sheller is built in as part of the plant, and endless belts convey the corn from the cribs to the sheller.

ADDITIONAL INFORMATION

Popcorn is grown in practically every state, but the main portion of the market supply comes from Sac and Ida counties, in Iowa, and Valley and Greeley counties, in Nebraska.

Iowa is the leading popcorn state. Ida and Sac counties vary greatly in acreage of popcorn from year to year. The following table gives popcorn acreage in these two counties for different years:

	1928	1929	1930	1931	1932	1933	1934	1935
Ida County...	5,710	6,251	9,393	3,687	2,600	903	2,437	6,239
Sac County...	7,824	10,780	17,725	8,830	7,405	3,037	5,804	11,582

Uses of popcorn.—Most of the popcorn is used as a confection. "Cracker-jack," "Checkers," and similar well-known delicacies are coated popcorn. Popcorn coated with cheese is a recent product. In handling the commercial grades of popcorn, the wholesaler must figure on a waste of 7 to 25 per cent. This waste is made up of kernels that will not pop, kernels that are mixed with dent corn and dust or broken pieces of cob that the sheller did not clean cut. Considerable popcorn flour is used commercially.

Why it pops.—Popping is caused by explosion of moisture contained in the horny, hard, dense starch of the kernel when heat is applied. If there is more than 15 per cent moisture or less than 10 per cent, the popping is likely to be somewhat imperfect. New crop popcorn will ordinarily get down to 15 per cent moisture by December or even earlier if it is stored in the

house. Popcorn stored in heated buildings often contains less than 10 per cent moisture, and therefore pops poorly. Popability may be restored by placing the popcorn outdoors for a few days or by placing 2 pounds of the shelled corn in a two-quart fruit jar and adding 2 or 3 tablespoonfuls of water, closing the jar tightly and allowing it to stand for a few days. The result should be the absorption of enough moisture to result in the optimum 13 per cent content. Good rice popcorn containing 13 per cent moisture will increase in volume eighteen or twenty times; Jap Rice, twenty-five to thirty times, and the large-grained eight-rowed types about fifteen times. Unless moisture conditions are just right, the yields will be lowered with all these types. Large increases in volume seem to be associated partly with a small kernel, partly with a deep, narrow kernel, and partly with an exceedingly dense, hard starch with no soft starch whatever.

SELECTED LIST OF REFERENCES

WEATHERWAX, P. The Popping of Popcorn. Proc. Ind. Acad. Sci. 1921. Pp. 149-53. 1922.

STEWART, F. C. The Relation of Moisture Content and Certain Other Factors to the Popping of Popcorn. N. Y. Bul. 505. 1923.

YEAGER, A. F. Popcorn Pointers. N. Dak. Circ. 24. 1924.

WILLIER, J. G., and BRUNSON, A. M. Factors Affecting the Popping Quality of Popcorn. Jour. of Agr. Res. Vol. 35. No. 7. Pp. 615-24. 1927.

BRUNSON, A. M., and BOWER, C. W. Popcorn. U. S. D. A. Farmers' Bul. 1679. 1931.

CHAPTER XIII

DEVELOPMENT AND PARTS OF THE CORN PLANT

THE two steps in the development of the corn plant are, first, germination, and second, growth. The essentials of these two steps in development are discussed in this chapter.

THE PLANT DEVELOPMENT

Germination.—The four conditions necessary for seed to germinate are: (1) vitality, (2) moisture, (3) heat, and (4) oxygen.

Under favorable conditions, corn may retain its vitality for ten years, but after the second year of storage the vigor of germination rapidly declines. As a practical proposition, seed corn should never be kept past the second year.

Moisture is necessary for seeds to germinate. Water readily penetrates and softens the seed coat of corn.

Corn requires a higher temperature to germinate than the small grains. It is a crop which germinates best under higher temperatures than usually prevail in May. Pammel, of the Iowa station, gives the following temperatures for the germination of corn: Minimum, 49.9° F.; maximum, 134.8° F.; optimum, 91.4° F. Cold-resistant strains of corn have been developed which will germinate when the temperature is as low as 43° F.

Oxygen is found in the seed, but not enough for germination. One of the reasons that corn does not germinate well on poorly drained soils is that the excess water in the soil excludes oxygen.

Growth.—Growth is cellular development. During early development, growth takes place in all parts at the same time, and after the first three weeks of growth all parts of the plant are formed. The five essentials for the growth of the corn

plant are: (1) vigor, (2) water, (3) light, (4) heat, and (5) plant food.

Vigor.—The plant must have inborn vigor. A seed may sprout, but if the seedling does not have strength a normal plant will not be obtained.

Water.—Corn requires large quantities of water to carry plant food and to keep it from wilting. Kiesselbach of Nebraska found that the rapidity of transpiration of corn varies directly with the temperature and the leaf area. A well-grown corn plant on a hot day in late July will transpire 5 to 10 pounds of water. This means that an acre of corn plants at this time of year is pumping up water from below and throwing it into the atmosphere at the rate of 18 tons daily, or 720 tons of water per acre, equivalent to 7 inches of rainfall, during July and August when the corn is most active.

Light.—Light furnishes the power which all green plants require. The process by which green plants take sunlight and store up its power is known as photosynthesis (light-building). In photosynthesis the carbon dioxide of the air enters the leaves through stomata (little holes) and is there combined by the power of the sunlight with water to make formaldehyde and later starch. Starch is literally imprisoned sunshine. Of all green plants, corn is one of the most efficient in capturing sunlight in large quantities and storing it away in the form of starch. In recent years it has been shown that the length of day has a pronounced effect on the flowering of plants.

Heat.—Corn requires a large amount of heat for development. In a Pennsylvania experiment, it was found that, during the twenty-two days preceding tasseling, those days with a mean temperature of less than 70° F. usually resulted in a growth of 3 to 3½ inches in twenty-four hours, whereas those days with a mean temperature of 75° or more resulted in a growth of 5 to 5½ inches in twenty-four hours. When the temperature in the daytime exceeded 85°, further increases did not seem to result in greater growth, probably because of moisture shortage.

Plant foods.—A fifth essential for growth is plant food. Corn requires the following chemical elements: Carbon (C), hydrogen (H), oxygen (O), phosphorus (P), potassium (K), nitrogen (N), sulphur (S), calcium (Ca), iron (Fe), magnesium (Mg). The expression, "C.HOPK(i)NS CaFe Mg (Mighty Good)" is a reminder of the essential chemical elements.

Oxygen, carbon and hydrogen are furnished by air and water, whereas the other elements are minerals in the soil. About 97 per cent of the corn kernel comes from the air and only 3 per cent from the soil. Each element is a specialist in its own field, and should it become deficient can not be replaced by another.

Oxygen is the most abundant element. It readily forms compounds with practically all other elements and constitutes about one-half of all known matter. It enters the plant in the compound, CO_2, a gas, and H_2O, water, where it is further changed by sunlight to build up the carbohydrates and proteins. The corn kernel is about 46 per cent oxygen.

Carbon is closely associated with plant life. It enters the leaves of the plant in the form of CO_2, where it is combined by sunlight with water brought up from the roots to form sugar, starches and the like. Carbon composes 45 per cent of the corn kernel.

Hydrogen is the third most abundant element in the corn kernel. It makes up 6.4 per cent of the corn kernel. Water is the one important source of hydrogen for plant growth. This element is combined by sunlight with carbon and oxygen to form the various carbohydrates and proteins within the plant.

Nitrogen is one of the most important and possibly the least appreciated elements. It forms one-sixth of the protein in plants, the formation of which would be stopped without it. Nitrogen:

1. Stimulates growth of foliage.
2. Imparts a deeper green color to foliage.
3. Delays the maturing process.
4. Controls the amount of other plant foods used.

About 1.5 per cent of the corn kernel is nitrogen.

Sulphur is an important constituent of both protein and protoplasm. In most corn soils there is a great abundance of sulphur. About 0.2 per cent of the corn kernel is sulphur.

Phosphorus is found in every cell of every plant, but it is especially abundant in the seed. It is of great value because it:

1. Causes rapid germination of seed and vigorous, early root growth.
2. Causes early ripening.
3. Causes greater formation of seed in proportion to stem.
4. Is essential to protoplasm.

About 0.3 per cent of the corn kernel is phosphorus.

Potassium plays an important rôle in the development of plant life. It seems to:

1. Encourage carbohydrate formation.
2. Aid in transference of starch.
3. Aid the plant in resisting fungus disease.

About 0.3 per cent of the corn kernel is potassium.

Calcium, which is fundamental both to plant and animal nutrition:

1. Aids in the development of root hairs.
2. Aids in the transportation of starch.
3. Neutralizes plant acids.
4. Has a strengthening effect on cell walls.

The corn kernel contains less than 0.1 per cent of calcium.

Calcium, phosphorus and potassium, when found in abundance in the soil, keep the corn plants from absorbing undue amounts of aluminum and iron and thus predisposing themselves to diseased joints, fired leaves and root rot.

Magnesium is found more particularly in the seed of plants. In this respect, it is the opposite of calcium. Practically all soils contain sufficient magnesium for plant growth. About 0.14 per cent of the corn kernel is magnesium.

Iron is second to oxygen in abundance in the earth's crust. It is never a limiting factor in production, as plants use only a

small amount of it. Nevertheless, iron is essential to chlorophyll production. By withholding iron from plants, no chlorophyll will develop, and consequently the plant makes no natural growth. Only small traces of iron are found in the corn kernel. Iron may act as a poison to corn, especially on tight clay soils which are low in phosphorus, calcium and available potash.

Of these ten essential elements, there are two, phosphorus and calcium (lime), which must be purchased and added to the soils of the Corn Belt to keep them productive. The other eight elements are usually present in abundance already or can be maintained through certain natural processes.

Roots

Corn, like other grasses, has a fibrous root system. The three types of corn roots are: (1) temporary, (2) permanent, and (3) brace roots.

The temporary root system is composed of the roots which are pushed downward from the tip of the kernel when it first sprouts. During the first two or three weeks after germination the temporary roots furnish most of the food which the young plant obtains from the soil. Later on, these roots either rot away from the plant or become unimportant except in the case of Hopi corn, which seems to rely on the temporary roots to bring up moisture from the deeper layers of the soil.

If the young corn plant, two or three weeks after germination, is dug up, it will be noted that between the kernel and the green stem above ground is a slender white stem. This is known as the mesocotyl. In the case of corn planted 1 inch deep, the mesocotyl is about 1 inch long, whereas in the case of corn planted 12 inches deep (Hopi corn is often planted this deep), the mesocotyl is 12 inches long. The temporary roots start from below the mesocotyl and go downward, whereas the permanent roots start from just above the mesocotyl.

Permanent roots.—The first two, three or even four nodes of the mature corn plant are separated by very short inter-nodes and are just below the surface of the ground. It is from these nodes just below the surface of the ground that the permanent

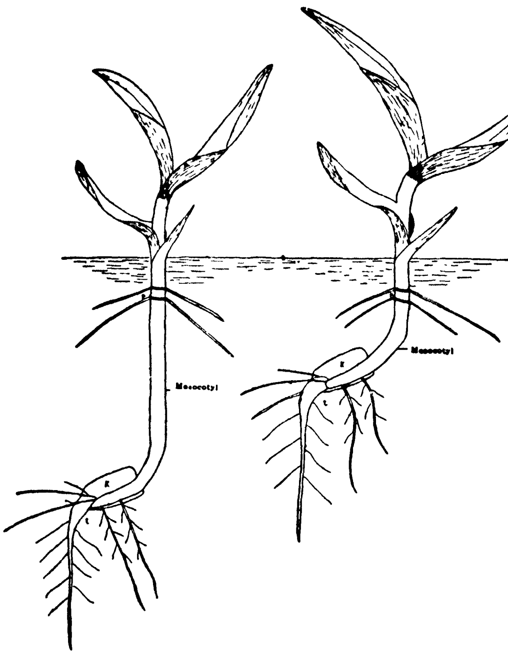


FIG. 60.—Illustrating how depth of planting influences length of mesocotyl and why the permanent roots (*p*) start just below the surface of the ground, no matter how deep the kernel is planted. The temporary roots (*t*) lose their importance after the permanent roots are well established, except possibly in the case of Hopi corn.

roots start out laterally from the nodes and then go downward to a depth of as great as 5 or 6 feet. The large, strong permanent roots are concentrated within a foot or two of the plant and only the small, fibrous roots reach the greater depth.

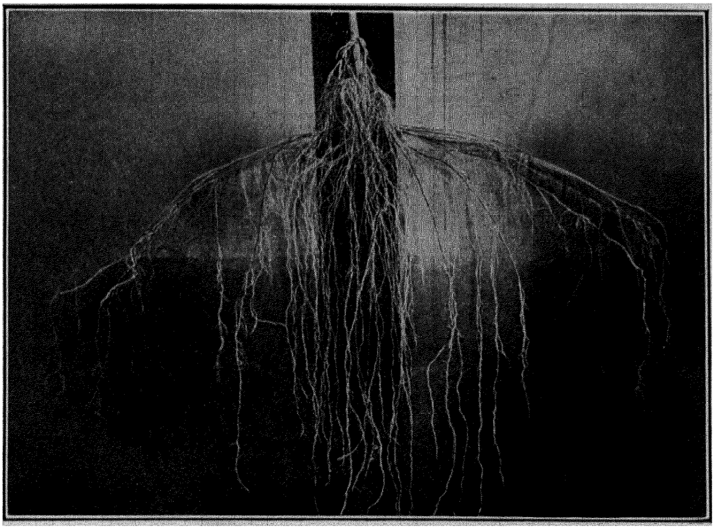


FIG. 61.—The root system of corn is much more extensive than most people suspect. This picture shows only a part of the roots. The great mass of the fine roots is lost on digging.

Courtesy of Iowa Station.

FIG. 62.—Brace roots.

Brace roots.—Brace roots differ from the permanent roots in that they come from the first two or three nodes above ground. In " down " corn or certain tropical varieties the brace roots may come out from nodes as high up as the fifth or sixth. Brace roots from the first node or two above ground are of very real help in maintaining an upright corn plant, but it is doubtful if brace roots from the higher nodes serve any useful purpose. Funk, of Illinois, says they are associated with diseased corn.

The roots of the corn plant:

1. Support and anchor the stalk.
2. Absorb plant food (soluble salts and water).
3. Excrete organic substances (such as carbon dioxide, and organic acids).
4. Render plant food soluble by action of the excretions.

Root growth is increased when the following conditions are present:

1. Large supply of oxygen.
2. Favorable temperature.
3. Plenty of moisture.
4. Good soil tilth.
5. Abundant available plant food.

The Corn Plant above Ground

Stalks.—The stalks of corn vary in height from $1\frac{1}{2}$ to about 30 feet. Some of the small, early popcorns will develop ears when only $1\frac{1}{2}$ feet high. Silage corns often make a growth of 15 feet.

The stalk is made up of nodes or joints, usually eight to twenty in number; the average number is about fourteen. In typical dent varieties of the central Corn Belt, the eighth node as a rule bears the ear. The node is the origin of all lateral outgrowths, such as roots, branches, leaves and ears. The portion of the stalk between the nodes is called the inter-node. The longer inter-nodes are toward the top and the shorter toward

the base. The stem of each inter-node is hollow on one side and it is on this hollow side that the leaf comes out. From the lower nodes on this hollow side there usually develops a small bud which does not amount to much except in the cases of the nodes which bear ears.

In cross-section, the stalk is made up of four main parts:

1. The epidermis, a thin transparent tissue, covers the outer part of the stalk. It is impervious to moisture and protects the stalk from insects and disease.
2. The stem wall is just beneath the epidermis. It is a woody layer, the hard, stiff portion of the stalk, made up of large numbers of fibro-vascular bundles, closely packed together. These bundles, stiffened by silica deposits, make the stem wall the " backbone " of the plant.
3. The center cavity of the stalk is filled with pith. It is a soft, spongy mass of tissue and serves as a storehouse for moisture and food. The fibro-vascular bundles in the pith are separated by large masses of pith.
4. The fibro-vascular bundles are channels for the transportation of plant food. They are found mostly in the woody stem wall and extend from the roots up through the stalk to the leaves and ears. They carry mineral plant food from the roots to the leaves and manufactured plant food to the ears and stalk. A little food is manufactured in the stem as well as the leaves.

Length growth takes place just above the nodes, and at the end of the stalk. The growth may be likened to a telescope. As a telescope unfolds, so does the cornstalk unfold. Therefore, the statement that we can "see corn grow over-night," is often made. Diameter growth takes place from the inside and not by added layers as in a tree. This type of diameter growth is called endogenous.

Suckers.—Suckers, or tillers, are branches which come from the nodes just at or just beneath the surface of the ground. The tendency to sucker is influenced by the variety, soil conditions, rate and method of planting. A large amount of available plant food will produce more suckers than soil in poor condition. Plentiful moisture increases the number of suckers.

Corn planted one kernel to the hill will send out more suckers than when planted at the rate of five kernels. Suckers have

their own root system and often bear ears. However, the ears as a rule are inferior to those upon the main stalk, often being borne on the tassel. It does not pay to pull off the suckers. At the Nebraska station, pulling off suckers was found to reduce the yield greatly.

Leaves.—The leaves on a corn plant are arranged alternately, conceal the grooved sides of the stalk, and are usually twelve to eighteen in number. The wavy margin, the result of the outside growing faster than the midrib, adds surface and flexibility to the leaf. The corn leaf is made up of three parts:

1. Leaf sheath. It comes from the node, and clasps or surrounds the stalk.
2. Blade, often incorrectly called the leaf. It is composed of the mid-rib, veins (parallel to mid-rib) and intracellular tissue.
3. Ligule, located at the hinge between the sheath and the blade. It is a collar which prevents water, dirt and insects from running down the sheath and stalk. At either end of the ligule is situated the auricle, or lobe-like portion. It is the light-green, wavy, triangular portion of the blade. It turns the water down the stalk onto the leaf below.

There are large numbers of small openings in the leaves known as stomata, through which carbon dioxide of the air passes into the interior of the leaf. The leaves, by means of their chlorophyll or green coloring matter, are able to use the energy of the sunlight to combine this carbon dioxide with water and ultimately to form sugars and starches. The leaves, besides manufacturing food, serve a useful purpose in evaporating surplus moisture. The leaves of an ordinary corn plant will evaporate on a hot July day from 5 to 10 pounds of water.

Flowers.—The male and female flowers of corn are located in spikelets on different parts of the same plant. This flower arrangement makes cross-pollination and fertilization the general rule in corn. It is estimated that not more than 5 per cent of corn grown under field conditions is selfed (pollen falls on silk and fertilizes ovule of the same plant). Kiesselbach found less than 1 per cent of self-fertilization under ordinary Nebraska conditions.

The male flowers are located in spikelets on the tassel of the plant. Each spikelet contains two flowers and each flower has three anthers, which contain the golden colored pollen. There are about 2000 pollen grains in each anther, and there are about 7000 anthers in each tassel. Therefore, each tassel may furnish about 15,000,000 pollen grains. This number is far in excess of the pollen required, because only one pollen grain is needed for the development of each kernel, and an ear requires only from 800 to 1000 pollen grains to bring about the development of all possible kernels. There are therefore 20,000 pollen grains produced for each kernel. The pollen is carried by the wind, and occasionally pollen may be blown half a mile. There is, however, much less mixture between fields than is commonly thought. Pollen ordinarily retains its vitality for about twenty-four hours. It may be killed in a few hours by heat and drouth.

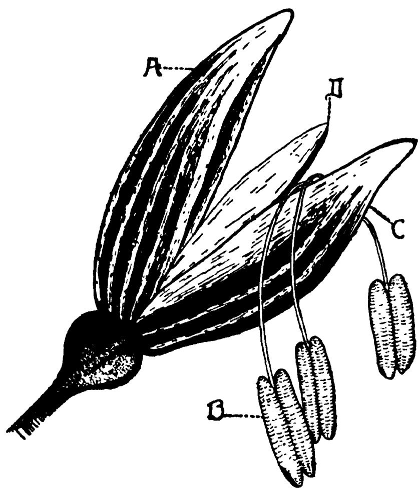


FIG. 63.—Staminate or male spikelet as borne by the corn tassel. (*a*) Upper flower, which has not yet opened enough to show anthers; (*b*) anther of the lower flower; (*c*) empty glume; (*d*) palea.

The tassel, as a rule, emerges before the silks do, and so pollen is available from one to three days before it is needed. Kiesselbach says: " Extensive observations have shown that in general the pollinating period of the tassel materially overlaps the silking period. Self-pollination might occur extensively were it not for the overwhelming preponderance of foreign pollen scattered promiscuously through the air."

The female flowers are located in pairs on the cob. Only one flower of each pair develops. An exception is the Country Gentleman variety of sweet corn, in which both flowers develop. An average ear of corn will have about 800 developed female flowers. Each of the flowers sends out a silk (style), and it takes from two to four days to send out all the silks. The kernels near the butt end of the ear send out their silks first. The end (stigma) as well as the surface of the silk is hairy and mucilaginous, to aid in catching the pollen grains. These silks are receptive to pollen before they emerge from the husk, and if they are not fertilized, they remain receptive for about two weeks.

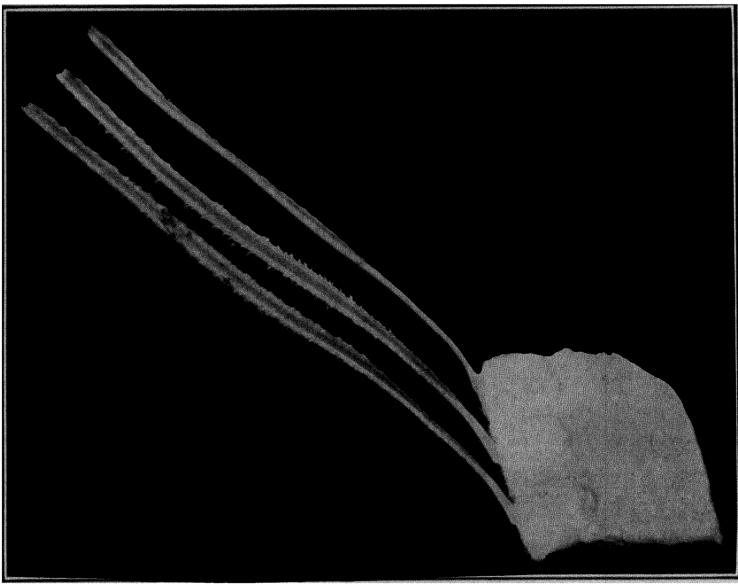


Fig. 64.—Illustrating how each unfertilized ovule on the young shoot has a silk (style) growing from it.

Fertilization.—Kiesselbach says: "Every kernel has its own silk and must be fertilized separately. In the process of

fertilization, pollen falling on the silk germinates and grows a pollen tube through the silk to the kernel, to which it conducts the two sperm nuclei. One of these nuclei fuses with the egg nucleus to form the initial embryo nucleus (true fertilization), and the other with the two polar nuclei, forming the initial endosperm nucleus (causing xenia, see Chapter XVI). This entire process has been found to be completed within approximately twenty-four hours' time. Fertilization is reflected in the discoloration and drying of the silks in from forty-two to seventy-two hours after pollination."

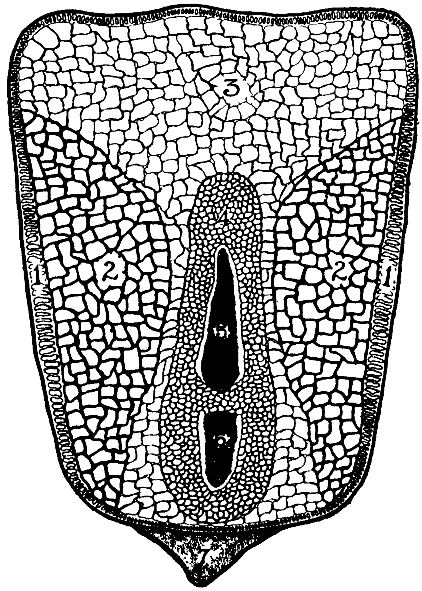


FIG. 65.—Typical kernel of dent corn. (1) Aleurone layer, which is colorless and almost impossible to detect with the naked eye, except in blue and a rare type of red corn; (2) horny or hard starch, which is colorless except in yellow corn; (3) soft starch, which is white in all colors of corn; (4), (5) and (6) together are the germ, (4) being the scutellum, (5) the plumule and (6) the radicle; (7) tip cap.

CORN EARS AND KERNELS

Ear compared with sucker.—The ear, including the shank and husks, may be likened to a branch or sucker of the main stalk. The nodes of the shank occasionally bear several small ears in addition to the main ear. Each husk represents the leaf sheath, and the streamer often found toward the top of the husk is comparable to the leaf blade. The cob is analogous to the tassel, in that it is a central spike which bears flowers. How-

ever, except in the case of freak ears, the cob has no lateral branches.

As a rule, Corn Belt varieties mature but one good ear of corn upon one stalk. Prolific varieties mature several ears upon one stalk.

Kernel.—The kernel is ripe in the ordinary season about fifty days after fertilization. Twenty days after fertilization the kernel is ripe enough to germinate, although it has only reached the milk stage by this time.

Stages of ripening are:

Milk stage—starch in the form of a fluid (about twenty days after fertilization).

Soft dough—starch soft and cheesy (about thirty-five days after fertilization).

Hard dough—starch hard and firm (about forty-two days after fertilization).

Glazed—(about fifty days after fertilization).

Ripe (about sixty days after fertilization).

The kernel may be divided into six parts:

1. Hull—the thin covering which encloses the entire grain. The hull is nearly colorless in commercial varieties except in red and calico corn.

2. Aleurone layer—a thin layer just beneath the hull. This layer is colorless and difficult to distinguish except in blue corn and a rare dull-red type. The red aleurone type is never grown commercially.

3. Soft starch—large, loose starch cells that occupy the crown and often the back and a part of the germ end of the kernel. It is often called white starch. In soft or flour corn, nearly all the kernel except the germ is soft starch.

4. Hard starch—small, compact starch cells and protein bodies occupying the sides and back of the kernel. This starch is translucent, whereas soft starch is opaque. In flint corn nearly all of the kernel except the germ is hard starch. The color of yellow corn is found solely in the hard starch, which means that yellow flint varieties are usually far deeper in color than either the soft or dent varieties. The hard and soft starch together make up what is commonly called the endosperm.

5. Germ—oily portion occupying most of the front side of the kernel. Composed of three parts, plumule, radicle and scutellum (or cotyledon). The plumule develops into the stem sprout and permanent roots. The

radicle develops into the temporary roots. The scutellum absorbs, changes, and transfers plant food for the seedling.

6. Tip cap—affords attachment of the kernel to the cob and protection to the germ. It is usually retained by the kernel in shelling. When broken off, it exposes the black covering of the germ. This covering is natural and not an unsoundness. Botanically, the tip cap is a bract which in the ancestors of corn almost completely enclosed the kernel.

SELECTED LIST OF REFERENCES

JONES, W. J., and HUSTON, H. A. Composition of Maize at Various Stages of Its Growth. Ind. Bul. 175. 1914.

DE BAUFRE, W. L. The Heating Value of Corn. Jour. Amer. Soc. of Agron. Vol. 15. No. 1. Pp. 1-6. 1923.

LATSHAW, W. L., and MILLER, E. C. Elemental Composition of the Corn Plant. Jour. Agr. Res. Vol. 27. No. 11. Pp. 845-60. 1924.

ALBERTS, H. W. Relation of Time of Planting Corn to the Time of Silking, Denting, and Senescence. Jour. Amer. Soc. Agron. Vol. 18. No. 5. 1926.

LAMPE, L. A Microchemical and Morphological Study of the Developing Endosperm of Maize. Bot. Gaz. Vol. XCI. No. 4. Pp. 337-76. 1931.

CHAPTER XIV

CLASSIFICATION OF CORN

CORN is a summer annual which belongs to the grass family. Such other common farm crops as wheat, oats, barley, rye, and sorghum belong to the same family. Incorrectly, flax and buckwheat are often called grasses. Botanists classify the corn plant as follows:

Botanical Division	Name	Characteristics
Family	Gramineae	Fibrous root system leaves alternate, parallel veins in leaves, split leaf sheath, ligule, stems cylindrical with solid nodes.
Tribe	Tripsaceae (Maydeae)	Male and female flowers in separate places on the same plant.
Genus	Zea	Grain borne on a lateral cob.

Besides zea (corn), three other common genera belong to the tribe Tripsaceae—*Euchlaena* (teosinte), *Tripsacum* (gamagrass), and *Coix* (Job's tears). Teosinte and gamagrass are described in Chapter XVIII. Teosinte readily crosses with corn and gamagrass with difficulty, but as yet there have been no successful crosses of either corn or teosinte with Job's tears. Job's tears is an ornamental garden plant. Large-growing, soft-shelled forms of Job's tears are cultivated as a grain crop in the Philippines and other tropical eastern countries.

There are several other genera (*Chionachne, Polytoca, Sclerachne,* and *Trilobachne*) belonging to Tribe Tripsaceae, which are found in India, but which seem as yet to be of no practical importance. From a strictly botanical point of view, there are no clear-cut species of the genus Zea. Before the

discovery of Mendel's law and its application to the genetics of corn, many distinct species of *Zea* were recognized. To-day most of these so-called species are looked on merely as interesting freaks which behave as Mendelian dominants or Mendelian recessives.

On the basis of kernel texture there are four common groups of Zea (corn):

1. Dent
2. Flint.
3. Sweet.
4. Soft.

Dent Corn

Dent corn is characterized by a depression in the crown of the kernel. This denting is caused by the unequal shrinkage of the hard starch found on the sides of the kernel and the soft starch which composes the crown. The character of the indentation varies all the way from a shallow dimple through a crumpled crease to a thin beak or hook. This last kind of indentation is characteristic of those dents with the highest percentage of soft starch toward the crown. Dent corn varies in color and in size and shape of ear. There is also a great variation in size and shape of kernel. Some ears of dent corn bear kernels of the extreme shoe-peg type, very narrow and deep. Other ears of dent corn bear kernels of the square type, very wide and shallow. In between are all gradations of kernel type.

The great diversity of type sketched in the foregoing, together with historical and genetic evidence, indicates that dent corn is not in any sense a species, but a conglomerate mixture. This mixture seems to have resulted from both accidental and intentional crossing of the large flint type (recognized as a distinct sort in the early part of the nineteenth century) with the gourd-seed, which seems to have been a late-maturing, rank-stalked type, bearing an ear with 22 to 36 rows of rough, deep, very soft, shoe-peg kernels. The ears were rather short, small-cobbed and very thick because of the great depth of grain. Some people have looked on the gourd-seed as being synonymous with

dent corn. That this is not true is indicated by the testimony of farmers who grew both dents and gourd-seeds. For instance, one farmer who grew both wrote:

"Gourd-seed is a large, rough, soft corn. It is later and has larger stalks and ears than the other varieties. It lacks the flintiness and weight for the same bulk as the others have. In

FIG. 66.—Relatives of corn. At left, Job's tears, showing female flower below and male flowers above. At right, gama grass, with female tassels in lower part of tassel and male flowers in upper part. (*a*) female flower (*enlarged*); (*b*) male flower (*enlarged*).

comparison with dent of my own raising, in feeding hogs, I thought it took about one and one-fourth bushels to go as far as one of my own corn. But cattle in particular will eat it more readily, as it is not so hard to masticate."

Mr. John Lorain, in his "Practice of Husbandry," published in 1825, refers to the common practice of mixing gourd-seed with other varieties:

"So prevalent are mixtures that I have never examined a

FIG. 67.—Teosinte-corn hybrid plant produced by a single kernel. Note large numbers of suckers and branches which bear tassels. A plant of this sort will often produce forty ears, but each ear carries only ten or fifteen kernels.

field of corn (where great care had not been taken to select the seed) which did not exhibit evident traces of all the corn in general use for field planting, with many others that are not used for this purpose. None can be longer nor more readily traced than the gourd-seed.

" The quantity of the gourd-seed mixed with the flinty yellow corns, may be determined, so as to answer the farmer's purpose. When the proportion of the former greatly predominates, the grains are pale, very long and narrow, and the outside ends of them are so flat (beaked) that but little of the indenture is seen. As the portion of the gourd-seed decreases in the mixture, the grains shorten, become wider, and their outside ends grow thicker. The indentures also become larger and rounder, until the harder corns get the ascendancy. After this, the outside ends of the grain become thicker and more circular. They also grow wider, and the fluted appearance between the rows increases. The indentures also decrease in size until they disappear, and the yellow, flinty variety is formed, but, as I believe, not so fully but that the latent remains will forever subject it to more or less change. It is more difficult to determine the quantity of big and little yellow flints, which may happen to be mixed with the gourd-seed, and at the same time with each other. The soft, open texture of the gourd-seed renders it unfit for exportation, unless it be kiln-dried."

Lorain previous to 1825, stated that true gourd-seed is white:

" It is invariably white, unless it has been mixed with the yellow flinty corns. Then it is called the yellow gourd-seed, and too many farmers consider it and most other mixtures original corns. I have often heard of original yellow gourd-seed corn, but after taking much trouble to investigate the fact, could never find anything more than a mixture. If there be an original yellow gourd-seed corn, it has eluded my very attentive inquiry from the Atlantic to our most remote western settlements."

Lorain also says that much of the corn which passes for white gourd-seed has been mixed with white flint.

Peter A. Brown, LL.D., writing a paper on corn for the Chester county, Pennsylvania, Cabinet of Natural Science, in 1837, refers to true gourd-seed as carrying twenty-four or more rows of kernels. He looked on ears carrying fourteen to twenty-two rows of kernels as mixtures of flint and gourd-seed. No reference is made to dent corn, although he lists thirty-five different types, seven of which he states were originated by

FIG. 68.—Teosinte on left contrasted with crosses of teosinte and corn on right.

mixing gourd-seed and flint. He mentions the King Philip as mixing especially well with gourd-seed.

According to the twelfth Smithsonian Institution report, the Mound-builders of Arkansas grew a type of corn which is "judged to be the variety known in the South as the gourd-seed corn."

Beverly, in his history of Virginia, written in 1705, states that the Indians grew a late flint and a late dent. "The other

has a larger grain and looks shriveled, with a dent on the back of the grain as if it had never come to perfection; and this they call She corn. This is esteemed by the planters, as the best for increase, and is universally chosen by them for planting; yet I can't see but this also produces the flint corn, accidentally among the other." Evidently there was some crossing of flint and gourd-seed to produce dent corn long before the time of John Lorain.

The genetic evidence in favor of the hypothesis that the typical dent varieties grown in the Corn Belt are a cross of the flint and gourd-seed corns consists in the ease with which inbreed-

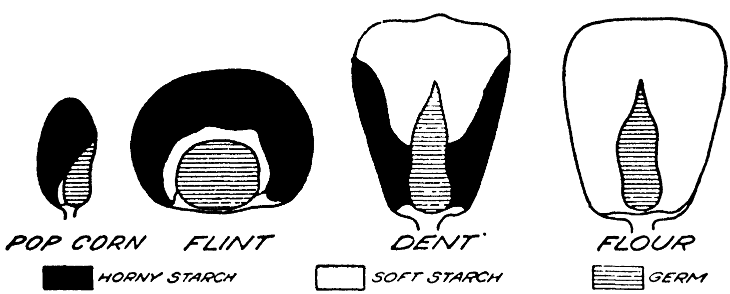


FIG. 69.—Diagram from U. S. Department of Agriculture, illustrating differences in kernel texture of different types ranging from flour corn to popcorn.

ing isolates out types which are practically pure flints. All of the experimenters who have done any extensive work in the inbreeding of dent corn have isolated strains of almost pure flint appearance. A few have also isolated narrow-grained, many-rowed, rough, starchy types which may be somewhat similar to the original Virginia gourd-seed as described by John Lorain. The gourd-seed type, however, does not stand up well under inbreeding unless there is at least some mixture of flint characteristics. Gourd-seed types, because of their lateness and susceptibility to disease, have thus far been difficult to isolate in their pure inbred form.

Of course, it is recognized that there may have been many other sorts mixed in forming the modern dent corn, but it is believed that the chief characteristics of dent corn as it is known in the Corn Belt to-day are due to the large flint and the gourd-seed.

Modern dents seem to contain varying percentages of flint and gourd-seed blood. Johnson County White appears to contain a high percentage of gourd-seed, whereas Northwestern Dent is unquestionably more than one-half flint. Reid Yellow Dent was formed by crossing the Gordon Hopkins corn of southern Ohio with the Little Yellow of Illinois. The southern Ohio corn of one hundred years ago presumably came largely to Ohio by way of Kentucky and Virginia, and it is likely that the late maturing Gordon Hopkins corn was rich in the blood of Virginia Gourd-seed. Little Yellow was a term often used to describe an early flint corn, and it is probable that Reid Yellow Dent was produced by selection by James Reid, following on the crossing by his father, Robert Reid, of a flint and gourd-seed type. At any rate, it is unusually easy to-day to isolate flint types out of all types of Reid except those which have been bred for the rough show type.

The hybrid heredity of dent corn and the consequent variability and possibility of securing unproductive as well as productive mixtures indicate that intelligent selection is probably more necessary with dent corn than with purer types.

Dent corn typically contains about 10 per cent protein, 68 per cent nitrogen-free extract, and 4.8 per cent fat. It is 1 to 2 per cent poorer in protein and 1 to 2 per cent richer in nitrogen-free extract than flint corn of the same moisture content. Shelled dent corn typically weighs 53 or 54 pounds per bushel, whereas shelled corn of the small seeded flints may weigh 60 pounds per bushel, and the flour corns may weigh only 50 pounds.

Flint Corn

Flint corn differs from dent corn in that it contains practically no soft starch; therefore, no indentation is formed. Most flints sucker profusely, and usually bear more than one ear per plant. Flint corns are good yielders and furnish excellent fodder. The corn meal made from flint corn is of superior quality. Most yellow flints are a much deeper yellow than yellow dents.

The four common classes of flint varieties are: (1) early flints, (2) medium flints, (3) tropical flints, and (4) popcorn.

The early flints are the earliest varieties of corn grown in the United States. They grow only 3 or 4 feet high, and bear the ear within a few inches of the ground. The color is variable, and the ear 6 to 7 inches long and usually carrying eight rows. This type is adapted to short seasons, high altitudes and dry conditions. Representative varieties are Gehu, Dakota White and Early Indian. Most of these early flints were developed by the Indians of the northwest with but very little improvement by the white man during the past thirty years.

The medium flint class consists principally of varieties that originated in New England, and the Middle Atlantic states. They grow from 5 to 7 feet in height, but are finer stalked than the dent varieties. They vary greatly in size and color of ear and in length of maturity. Most of them are eight-rowed. Because of their fine stalks and numerous leaves, they make an excellent quality of fodder and silage. Representative varieties are Longfellow, King Philip, Smut Nose and Mercer. Both the early and medium flints sucker considerably and carry many streamers on their husks.

The tropical flints are not well known in the United States. Presumably, Columbus found tropical flints growing on the West India islands and introduced them to Europe. Many of the common flints of Italy, the Balkan States and Argentina seem to be tropical flints. The tropical flints, as modified by selection in these countries, require about 120 days to mature. Many of them do not sucker. The kernels usually are narrower

and deeper than with the medium class of flints. Oftentimes the ears carry twelve, fourteen, or even sixteen rows.

Popcorn differs from the other flints in that it contains an even higher percentage of hard starch, the kernels are usually much smaller, and the hull, in proportion to the size of kernel, is tougher and thicker. Because of these characteristics, the kernel, when heated, has the ability to pop better than the other flints. Erwin, of Iowa State College, is of the opinion that popcorn is probably just a mutant of flint corn. Popcorn is discussed in Chapter XII.

In spite of great variability among all four classes of flints, just described, there is reason to think that they are more uniform in their characteristics than the dents.

Sweet Corn

Sweet corns may be of the dent type (Evergreen) or the flint type (Golden Bantam), and also of soft-corn types. Sweet corn, therefore, has the possibility of being one of the most variable of all corn types. The only distinguishing characteristics of sweet corn are wrinkled kernels and translucent, hard starch, which does not mature normally, apparently remaining in the sugar stage much longer than in ordinary corn. Sweet corn contains a much higher percentage of fat and protein than dent corn.

Erwin states that "sweet corn came from field corn and we are indebted for numerous varieties to the New England pioneers."

Soft Corn

Soft varieties of corn are grown to only a very limited extent. They are also known as "squaw" corn and "flour" corn. Soft corn is usually similar to flint corn in plant and ear characters, but differs in that the kernels are composed largely of soft starch instead of hard starch. Like flint corn, it has no dent (sometimes there is a slight dent in Hopi Indian corn). The horny starch in soft corn is such a very thin shell at the sides

of the kernel that it is impossible for any strain of this corn to be deep yellow in color (the yellow color of corn is found only in the horny starch).

Strains of soft corn are Brazilian, Flour, Hopi, and the Blue Flour of the Nebraska and Dakota Indians.

OTHER TYPES

Kernel texture, while convenient for practical purposes, is only one basis of classifying corn. Geneticists have studied hundreds of distinct types which the botanists of a generation ago would have dignified with Latin names as distinct species. Some of these types are:

1. Pod corn—each kernel enclosed by a husk as well as the entire ear.
2. Brachytic corn—short-jointed corn which is normal in every respect except that the joints are only half the normal length. There is the usual number of leaves.
3. Purple-leaved corn—the leaves and husks are a deep, beautiful purple.
4. Japonica, or striped-leaved corn.
5. Hairy corn—hairs on the stems and leaves.
6. Ramosa corn—ear a round cluster of kernels without a true cob. (Discovered at the Illinois station.)
7. Corn bearing ears with lateral branches at the base of the cob.
8. Tassel ear corn—ears borne on tassels.
9. Waxy corn—logically, this should be included as a fifth member of the classification on kernel texture. The carbohydrates of the kernel are stored in the form of dextrin, instead of as starch. It is not shriveled, however, like sweet corn.
10. Starchy sweet corn –like waxy corn, this logically should be included with the classification on basis of kernel texture. The upper part of the kernels is translucent and horny like sweet corn, and the lower part is starchy. This corn is grown by certain Mexican and Peruvian Indians.

There are many more rather freakish types of this sort which have as legitimate claim, from a botanical point of view, to be known as species of *Zea* as do dent corn, flint corn, sweet corn, and soft corn. From a practical point of view, however, this classification into four groups, on the basis of kernel texture, seems best.

SELECTED LIST OF REFERENCES

COLLINS, G. N. The Origin of Maize. Jour. Wash. (D. C.) Acad. Sci. Vol. II. Pp. 520-30. 1912.

WEATHERWAX, P. The Evolution of Maize. Bul. Torrey Botanical Club. Vol. 45. No. 8. Pp. 309-42. 1918.

COLLINS, G. N. Maize: Its Origin and Relationships. Jour. Wash. (D. C.) Acad. Sci. Vol. VIII. No. 2. Pp. 42-3. 1918.

JONES, D. F. The Origin of Flint and Dent Corn. Jour. Heredity. Vol. XV. No. 10. Pp. 417-9. 1924.

KEMPTON, J. H. Maize and Man. Jour. Heredity. Vol. 17. No. 2. Pp. 32-51. 1926.

MANGELSDORF, P. C., and REEVES, R. G. The Origin of Indian Corn and Its Relatives. Tex. Bul. No. 574 (Monograph). Pp. 1-315. 1939.

CHAPTER XV

VARIETIES OF CORN

ALTHOUGH there may be a thousand varieties or strains of corn, a few leading ones make up a large percentage of the corn grown. A few of the leading open-pollinated varieties in different sections of the Corn Belt are:

SECTION OF CORN BELT	LEADING VARIETIES
Northern	Silver King, Minnesota No. 13, Northwestern Dent, Wimple, Golden Glow, Golden King.
Central	Reid Yellow Dent, Silvermine, Boone County White, Leaming, Ioleaming.
Eastern	Boone County White, Reid Yellow Dent, Johnson County White, Leaming, Funk Yellow Dent, Clarage.
Western	Reid Yellow Dent, Silvermine, Hogue Yellow Dent, Freed White Dent, Calico.
Southern	Reid Yellow Dent, Boone County White Dent, St. Charles White, Kansas Sunflower.

REID YELLOW DENT

Reid Yellow Dent was originated by an accidental cross between a rather late, light-reddish colored corn and a small, early yellow corn. Robert Reid, the originator, brought the reddish colored corn, known as Gordon Hopkins corn, to Illinois from Brown County, Ohio, in 1846. Because of a poor stand in 1847, a small yellow corn, probably a flinty type, was used in replanting the missing hills, and so the cross occurred. James L. Reid, a son of Robert Reid, improved the hybrid by selection, his best work being done from 1870 to 1900. He won a prize with it at the World's Fair in 1893, and as a result it soon became widely distributed.

Ears of this variety are 9 to 10 inches long and 7 to 7½ inches in circumference, for the central Corn Belt, but vary somewhat with the section of the Corn Belt in which they are grown. The ear is slightly tapering, the rows are closely spaced, distinctly dove-tailed, and average from sixteen to twenty-two in number. The kernels are slightly keystone in shape, of medium depth and narrow to medium in width, with a square crown and a smooth to rough indentation. The normal color is yellow, but the reddish tinge of the Gordon Hopkins often appears. The cobs are inclined to be small and are dark red in color. The stalk is rather heavy, tall, and leafy. The ears are often borne a little too high on the stalk unless care is taken in selection.

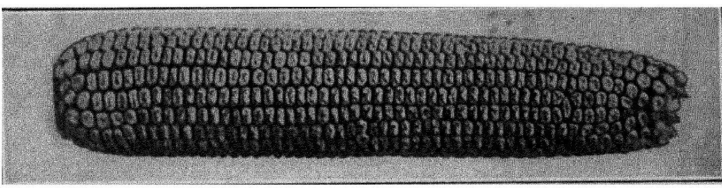


Fig. 70.—Reid corn (rough type).

Reid Yellow Dent requires from 110 to 120 days to mature and should be classed as medium late. At present, owing to wide adaptability, it is the most common yellow variety in the Corn Belt, although the type necessarily has been modified to fit many different conditions. The type as now generally grown is rougher than the type which Reid originally preferred.

Outstanding strains of Reid corn are Iodent, Black, McCulloch, and Krug. Iodent is an early Reid developed by L. C. Burnett, after years of painstaking ear-row work at the Iowa station. Black has resulted from a cross of Iodent and a late show type of Reid, made by Clyde Black, of Dallas County, Iowa. McCulloch was produced by selection from a cross of a

small amount of Pride of the North with a large amount of Reid. Fred McCulloch, of Iowa County, Iowa, was the originator. George Krug, of Woodford County, Illinois, in 1903, crossed Gold Mine with a Nebraska strain of Reid and has developed Krug corn by selecting continuously for a smoother, rather small-eared type. All these strains have demonstrated their ability to yield. (See Chapter XVII, "Corn-yield Contests.")

Boone County White

Boone County White was originated in Boone County, Indiana, by James Riley. In 1876, he obtained his foundation stock, which was a large, coarse, late-maturing variety of corn known as White Mastodon. The stalk is heavy and rank, with short inter-nodes and abundant foliage. The ear is $9\frac{1}{2}$ to $10\frac{3}{4}$ inches long and $7\frac{1}{2}$ inches in circumference. The shape is nearly cylindrical, with straight rows, sixteen to twenty-two in number and of medium spacing. The butts are rather large and open, with shallow cavity. The cob is white and rather large and heavy. The kernels are thick and blocky, medium to wide, and medium to deep. The normal color is a creamy white, and the usual indentation is rather rough.

Boone County White is a late-maturing variety of corn, requiring 120 to 125 days. It is grown chiefly in the southern Corn Belt, and on account of its late maturity is not well adapted to the remainder of the Corn Belt. However, it is a popular corn on the rich land of the sections where it is adapted. Boone County White and the related Johnson County White are far more widely grown than any other white Corn Belt varieties.

Leaming

Leaming corn has been developed since 1856, according to W. A. Lloyd, of the Ohio station. It did not originate in 1826. Mr. Lloyd says: " Manifestly, J. S. Leaming could not, as it is

often stated, have originated this corn at that time (1826)." J. S. Leaming, in developing Leaming corn, placed special emphasis on early maturity. He thought that a rather short stalk, heavy at the butt and tapering rapidly, bearing a tapering ear, was the type that matured earliest. The original Leaming corn ripened in from 90 to 100 days.

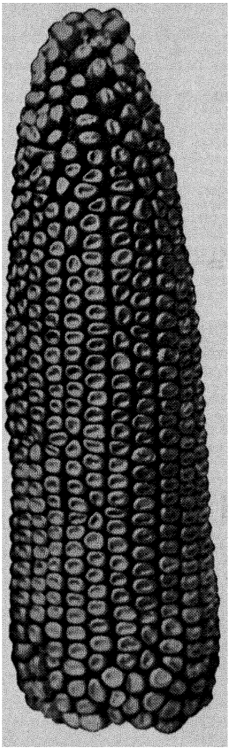


FIG. 71. — Leaming corn (original type, as favored by J. S. Leaming).

The present-day type of stalk is still medium in height. The ear is 9 to $10\frac{1}{2}$ inches in length and 7 to $7\frac{3}{4}$ inches in circumference, with large, rather open butt and distinctly pointed tips. The rows vary from sixteen to twenty-four in number. The kernels of true Leaming are medium in depth, very thick and rather narrow. Leaming is a deeper yellow than most yellow dents. The indentation varies from smooth to rough, but in the original Leaming the smooth type was preferred.

It is grown most extensively in the central and eastern parts of the south-central Corn Belt and to some extent in adjoining sections of the north-central Corn Belt. Leaming became popular in the eighties and nineties, partly because of the publicity it received from winning prizes at the World's Fair in Paris in 1878.

SILVERMINE

Silvermine originated with J. A. Beagley, of Sibley, Illinois, who started with a sample of white corn which won a prize at the Ford County, Illinois, institute in 1890. The Iowa Seed

Company, of Des Moines, bought his entire crop in 1895, for $1000, and originated the name, Iowa Silvermine.

Silvermine is not a rank-growing variety, and even on rich soil it does not produce as heavy foliage as some varieties. The stem is of a fine texture and there is little coarseness about the joints. The ears are medium in size, being from 9 to 10 inches in length and from 7 to 7½ inches in circumference. They are cylindrical for about two-thirds of the length of the ear and then slowly taper off at the tip. The kernels are of medium depth and width, but thin in comparison with their width. The dent varies from smooth to rough. The color is creamy white. The deep kernel and small cob of Silvermine give it a high shelling percentage.

Silvermine is adapted to a wide range of climate and soil and has the reputation of doing well on poor soils. It is a medium early corn, maturing in 110 to 115 days, and is well adapted to central Corn Belt conditions. It is the leading white variety just north of the section where Boone County White is widely grown.

Silver King

Silver King, also known as Wisconsin No. 7, was first developed as a variety by H. J. Goddard, of Fort Atkinson, Iowa, who brought a bushel of the seed from Indiana to Fayette County, in 1862. Mr. Goddard selected for early maturity and yield. To improve the yield, he selected fairly large ears with deep, wide kernels, a medium to small cob and closely spaced rows. One of the valuable characteristics of this corn is its freedom from barren stalks. The ear is 8 to 9 inches long and 6¾ to 7½ inches in circumference. There is a gradual taper from butt to tip, and the rows average sixteen to the ear and are inclined to be wavy. Silver King has creamy white kernels which are very wide, of medium depth and thickness, slightly keystone in shape. The usual indentation is rough. It is one of the earliest maturing of the prominent varieties, maturing in

100 to 110 days. It is the leading white variety in the section of the Corn Belt immediately to the north of the Reid Yellow Dent territory. Some Silver King is grown as far south as Missouri, but only for late planting or replanting.

Kansas Sunflower

Kansas Sunflower originated from an early yellow variety of corn introduced from Iowa into Douglas County, Kansas, in 1887. John Moody, of Eudora, Kansas, obtained seed of this variety in 1890, and continued growing it for some time, carefully selecting the seed each season. Five years later he sold his entire crop to the Barteldes Seed Company, of Lawrence, whence it was distributed under the name of Kansas Sunflower.

The stalks grow from 8 to 9 feet in height, are fairly leafy, and under favorable conditions sucker rather badly. The variety is a hardy and vigorous grower. The ears are 9 to 10 inches in length and 7 inches or slightly less in circumference. The ears are rather slender and taper slightly, carrying ordinarily fourteen to eighteen rows of kernels. The kernels are broad, medium deep and of medium indentation. The grain of Kansas Sunflower is a bright, rich yellow.

Kansas Sunflower is a medium late variety, which ripens in 120 to 125 days. It is well adapted for growing throughout eastern Kansas. Because of the slender ears and lack of show characters, Kansas Sunflower has not been a very popular variety, even though it has consistently given good results.

St. Charles White

The St. Charles White is a native of St. Charles County, Missouri, where it has been grown for a great many years. Two types of this corn are recognized—the small St. Charles and the large St. Charles, the former being slightly earlier and better adapted to thin lands.

The cobs possess the striking peculiarity of being blood-red in color. St. Charles White is a late-maturing variety, averaging 125 to 130 days for complete maturity. It is a rank-growing variety with adaptation similar to Boone County White. It is useful as a silage variety.

Commercial White

The Commercial White corn was originated by P. E. Crabtree, of Barton County, Missouri, who developed the corn by selecting the white-cobbed ears of the St. Charles White. The ideals which have been kept in mind in selection are uniform kernels of medium depth, with a low amount of crown starch and large germs.

The ears are larger in circumference and more cylindrical than are those of the St. Charles White, but often taper quite abruptly at the tip. The rows are straight and distinctly paired. The butts have a tendency to be flat and often have a large shank. The kernels are broader than those of St. Charles White and are only of medium depth. They are thick and a trifle more wedge shaped than the St. Charles White and more rounded at the top. They possess a small amount of crown starch and are pearly white in color. The indentation is medium smooth.

Commercial White is a late maturing variety which requires 125 to 130 days for complete ripening. It is a tall growing corn, averaging about 9 feet for the state, and very leafy. The stalks are very strong and stocky. The cob, which has a tendency to dry slowly, prevents as high a grade of market corn as either Boone County White or St. Charles White. It is a good silage variety. Missouri co-operative tests have shown it to be the highest yielding variety on the black prairie uplands of the state.

Minnesota 13

Minnesota 13 was originated by ear-row breeding at the Minnesota experiment station, from seed purchased in 1893, from a St. Paul seed company. Probably it was from Pride of the North. The ears are 7 to 8 inches long and 6½ inches in circumference. There are twelve to sixteen rows, and the ears are slightly tapering. They have yellow kernels and a red cob. The kernels are shallow and have a dimpled dent. It is an early-maturing but heavy-yielding variety, adapted to the region extending from southern Minnesota northward.

Ioleaming

In 1923 two brothers, Stuart and Paul Smith, recent graduates of Iowa State College, and their brother-in-law J. R. McNeilley of Jones County, Iowa, crossed Iowa 119, an early strain of Reid Yellow Dent developed by the Iowa Agricultural Experiment Station, and a small early strain of Leaming developed by Don McCorkingdale of Sac County, Iowa, to develop Ioleaming. It is an early yellow corn adapted to the northern and central portions of Iowa, where it is now fairly widely grown. This variety has smooth, thick kernels and many of the characteristics of what is generally recognized as a smooth type of dent corn.

Golden King

This variety was first entered in the 1923 Iowa Corn Yield Test by William McArthur of Cerro Gordo County, Iowa. It is an early yellow corn adapted to northern Iowa, southern Minnesota, and other regions, such as western Oregon, requiring early strains of corn. The variety is characterized by early maturity, high yielding ability and vigorous growth for an early strain of corn. These characteristics have been intensified by seed selection practiced by McArthur, who also named the variety.

Clarage

Clarage is a standard variety of yellow corn in Ohio where it is widely grown and considered to be of good yielding ability. It was developed by Edmund Claridge of Fayette County, Ohio. The ears of this variety have been described as tapering, 9 inches in length, 6 to 7½ inches in circumference, and with fourteen to eighteen rows of grain. Early maturity was the most important characteristic for which Claridge selected this variety from the corn he found growing in Ohio in the early nineteenth century.

Golden Glow

Golden Glow, which is the most popular yellow dent in Wisconsin, was originated by the Wisconsin station by crossing a Wisconsin strain of Minnesota 13 with a somewhat later and larger-eared variety long grown in Wisconsin under the name of North Star. After several years of selection, the new variety was distributed by the Wisconsin station.

Hogue Yellow Dent

Hogue Yellow Dent has been grown by R. Hogue, of Crete, Saline County, Nebraska, since 1885. He obtained the corn from Lancaster County, Nebraska. The history of the corn previous to that time is not known. Mr. Hogue has carefully selected the seed each year, having particularly in view a deep kernel. The result is an ear with rather deep kernels, deeply indented, and fairly late maturing. One characteristic of the corn is a thick, medium tall stalk with long, broad leaves, giving a large amount of foliage. The variety has never been intentionally crossed since Mr. Hogue obtained it. Mr. Hogue has never undertaken to select for uniformity of kernel type or ear; in fact, he has always intentionally selected and mixed several ear types for his seed supply.

It requires approximately 120 days to mature and is not well suited to conditions of a shorter growing season. It is extensively grown in eastern Nebraska and central Kansas.

Johnson County White

Johnson County White was originated by J. D. Whitesides in Johnson County, Indiana, in 1893, from a cross between Boone County White and Forsythe's Favorite, and was improved by several farmers.

The ears are about 9½ to 10½ inches long and 7½ inches in circumference. They are about the same size as Boone County White, but are slightly more tapering. The kernels are narrower and more nearly square at the crown than those of Boone County White. They are also deeper, rougher, and more starchy in composition, which gives them a starchy white color.

Johnson County White matures in 120 to 125 days, and is adapted to the southern Corn Belt, but is too large and late maturing north of southern Iowa. It has replaced Boone County White in many localities.

Freed White Dent

This variety was developed by J. K. Freed, of Scott County, Kansas, who began by selecting a badly mixed variety of a local corn for the purpose of establishing a more uniform type of ear and kernel. The original source of the foundation stock is unknown. The corn has been grown in western Kansas for at least thirty years.

Freed White Dent ranges in height from 6 to 8 feet, depending on the growing conditions. The stalks are sturdy, fairly leafy, and likely to sucker extensively under favorable conditions, but not to so great an extent as most other western developed varieties. The ears are 7 to 8½ inches long and 6½ to 6¾ inches in circumference. The number of rows of kernels

varies from twelve to sixteen. The kernels are rather shallow and medium in width and thickness. The dent is smooth and the kernel texture is flinty.

Freed White Dent is an early variety, which matures in 105 to 110 days. It is primarily adapted for growing in western Kansas and on the uplands in west-central Kansas. Because of its hardiness and vigorous growing habits, it is an exceptionally high-yielding early corn for growing anywhere in Kansas.

Northwestern Dent

The origin of Northwestern Dent is doubtful, but almost certainly was the result of crossing a dent and a flint, one of which was red. It is a semi-dent variety that normally produces more suckers and leaves than any other common dent. The ear is 6 to 9 inches long with ten to fourteen rows of kernels. The kernels are red with a white or yellowish crown. It is a hardy corn adapted to the extreme northern part of the Corn Belt, and is the best-known variety in the northwest.

Wimple Yellow Dent

Wimple Yellow Dent was developed by Mr. Wimple, of Beresford, South Dakota. The ears are 8 to 9½ inches in length and tapering in shape. The kernels are wide with a short beak dent and are lemon yellow in color. It has a larger ear and considerably heavier stalk than Silver King. Wimple Yellow Dent matures in 105 to 115 days. It has been grown in the northern part of the Corn Belt for a number of years. The originator also developed a smoother, earlier strain.

Funk Yellow Dent

Mr. Funk, of McLean County, Illinois, secured the original seed from James Reid, over thirty years ago. Since that time, popular opinion has demanded several variations in type. For a time, it was bred for a rough type, but in recent years the emphasis has been on the smooth.

A popular utility type of corn is Funk Yellow Dent, Strain 176-A. The ears are 9 to 11 inches long and 7 to 8 inches in circumference. This variety conforms just as nearly as possible to the utility type score card. The story of how this strain of corn has been developed from Funk Yellow Dent is as follows:

"In germinating several hundred bushels of seed corn during the winter of 1915 and 1916, we occasionally noted a few ears on the germinator that were remarkably free from molds and rotting and that possessed unusual vigor and magnificent root development. These ears proved their superiority in the field during the following season, by far outclassing everything else in the experimental plots. The progeny from these champion mother ears have been multiplied and improved further by special breeding methods."

Calico

Strains of Calico have been developed by different growers. The shape of the kernel, dent, character of stalk, and length of growing season vary considerably, depending upon the grower. The ears are from 9 to 11 inches long and almost cylindrical. The kernels are variegated in color, ranging from pink to red, depending upon the amount of red in the striping, but there are sometimes groups of kernels of solid white, red, or yellow. It is quite widely distributed and has no fixed characteristics. Many strains are early to medium maturing. These are well adapted to western Corn Belt conditions.

Bloody Butcher

Bloody Butcher is a name applied to strains having a deep red grain. The crown of the kernel varies in color for the different varieties, but is usually lighter than the remainder of the kernel. As a rule, Bloody Butcher corn is not any more productive than corn of any other color. Like Calico, the different varieties of Bloody Butcher vary greatly, as do those of

the white and yellow varieties. The red color is in the hull only; beneath the hull, some Bloody Butchers are white and some are yellow.

Other Varieties

Several of the important varieties in addition to the ones just described are:

Early White Dent.—Marten White Dent (Great Plains); Payne White Dent (Great Plains); Pioneer White Dent (Northwest); Rustler White Dent (Northwest), and Webber Early Dent (Great Plains).

Medium to Late White Dent.—Brazos White (Texas); Champion White Pearl (Illinois); Chisholm (Southwest); Cob Pipe or Collier (Missouri); Democrat (Illinois); Easterly White (Illinois); Eureka (general); Farmer's Pride (eastern Corn Belt); Farmer's Interest (eastern Corn Belt); Faulkner (Illinois); Forsythe (Kansas); Hammett (Kansas); Iowa Ideal (Iowa); McAuley (Kansas); Mexican June (Southwest); Munikhysyen (Southeast); Nebraska White Prize (Nebraska); Pride of Saline (Kansas); Roseland (Kansas); Shawnee White (Kansas); Sherrod White Dent (Kansas); Surcropper (Southwest); Tuxpan (Southwest); Vogler White Dent (Indiana) and White Wonder (Oklahoma).

Early Yellow Dent.—Ardmore Yellow (South Dakota); Brown County Yellow (Northwest); Golden Surprise (Ohio and Illinois); Kossuth County Reliance (Iowa); Minnesota King (Minnesota); Murdock (Wisconsin); Pride of the North (general); Robertson Yellow Dent (Northwest), and Falconer (Northwest).

Medium to Late Yellow.—Bear Paw (Ohio); Cartner (Missouri); Champion (Ohio); Cuppy (Ohio); Darke County Mammoth (Ohio); Early Yellow (Indiana); Ferguson (Southwest); Giant Beauty (Southeast); Golden Beauty (Missouri); Golden Eagle (Illinois); Golden Gem (Southeast); Golden King (Illinois); Goldmine (general); Hiawatha (Kansas);

Hildreth (Kansas); K. B. Yellow Dent (Iowa); Lancaster Sure Crop (Pennsylvania); Legal Tender (general); Midland Yellow (Kansas); Monitor (Ohio); Riley Favorite (Indiana); St. Charles Yellow (Missouri); Shroll Yellow Dent (Ohio); Skipper (Southeast); Wabash Yellow (Indiana); Western Plowman (Illinois), and Yellow Jumbo (Ohio).

Miscellaneous Dent.—Blue and White (scattered); Devolid (Ohio); Early Red (scattered); Hackberry (Ohio); Hecker Red (Illinois); Lenocher Homestead (Iowa); Minnesota 23 (Northwest); Old Glory (Texas); Rotten Clarage (Ohio); Strawberry (general); Stony Hill White Cap (New York); Strout Red (Illinois); Swadley (Great Plains), and White Cap Y. D. (general).

Cotton Belt single ear.—Lowman (yellow); Shenandoah White (white); Southern Beauty (white); Wyatt Improved (yellow); Hickory King (white).

Cotton Belt prolific.—Bigg Seven Ear (white); Cocke Prolific (white); Garric (white); Hasting Prolific (white); Hickory King (white); Jarvis Golden Prolific (yellow); Marlboro Prolific (white); Mosby (white), and Sanders (white).

New England flints.—Hall Gold Nugget; King Philip; Longfellow; Mercer; Rhode Island; Sanford White; Smut Nose.

Northwestern flints.—Assiniboine; Burleigh County Mixed; Cassia County; Dakota White; Fort Peck Indian; Gehu; Howe's Alberta.

Southern flints.—Creole.

Argentine yellow flints.—Canario; Colorado, and Piamontese.

Australian dents.—Fitzroy and Red Hogan.

Italian yellow flints.—Cinquantino; Nostrano Isola; Pignoletta d'oro; Rostrato, and Scagliolo.

Soft corn.—Ivory King; Mixed; Rea, and Brazilian Flour.

South African.—Potchefstroom Pearl; Natal Eight-row; Hickory King.

SELECTED LIST OF REFERENCES

STURTEVANT, E. L. Varieties of Corn. Office of Exp. Sta. Bul. 57. 1899.

HUGHES, H. D. Silver King—A Corn for Northern Iowa. Iowa Bul. 138. 1913.

CUNNINGHAM, C. C., and WILSON, B. S. Varieties of Corn in Kansas. Kans. Bul. 227. 1921.

DUNGAN, G. H., and BURLISON, W. L. Productiveness of Certain Varieties of Corn in Illinois. Ill. Bul. 294. 1927.

HUGHES, H. D., ROBINSON, JOE L., and BRYAN, A. A. High Yielding Strains and Varieties of Corn for Iowa. Iowa Bul. 265. 1929.

OLSON, P. J., and WALSTER, H. L. Corn in Its Northern Home. N. Dak. Bul. 257. 1932.

CHAPTER XVI

CORN BREEDING

Special corn-breeding methods do not pay on the average farm. Most farmers who have a good, acclimated variety are justified in doing nothing more than picking well-matured, solid ears, free from mold, every fall before frost. In addition, it may be well to see that the ears come from stiff stalks and are borne at a convenient height from the ground. Suggestions along this line are given in Chapter I.

Every few years, however, it is a good plan on one side of the field to grow side by side with the home variety of corn another sort which has a well-founded reputation for high-yielding power. If this supposedly high-yielding corn from the outside does unusually well, it may be a good plan to start all over with it or to mix it with the home corn. No special methods are necessary in this kind of corn breeding. Practical farmers have followed this general plan for fifty years, and only recently has it become apparent that a better method (use of hybrids) exists.

Four general methods of corn breeding have been practiced by corn breeders: (1) selection, (2) ear-row breeding, (3) cross-breeding and (4) inbreeding followed by crossing.

Selection

Nearly all commercial varieties of corn have been formed by selection preceded oftentimes by a certain amount of cross-breeding. The famous Illinois experiments started by Cyril G. Hopkins in 1896 and maintained for many years by Louis H. Smith have demonstrated that unusual changes in type may be

obtained by long-continued selection. After eight or ten years of selection for low ears at the Illinois station, they obtained a strain which on the average carried its ears less than 2 feet from the ground, whereas another strain developed from the same original Leaming, but selected for high ears, carried its ears more than 7 feet from the ground. After twenty years, a strain of corn selected for high oil contained over 10 per cent on the average, as contrasted with 2 per cent for the strain selected for low oil. In like manner, a high protein strain containing 16 per cent protein was developed and a low protein strain containing 6 or 7 per cent. In every case but one, however, these

FIG. 72.—Low ear and high ear corn at Illinois Station, developed by selection from same original Leaming.

selections resulted in reduced yielding power. The one exception was the strain selected for two ears, which at last reports from the Illinois station, was still yielding about as well as Reid corn. The other selections have yielded on the average only about three-fourths as well as Reid corn. It seems that selection for one particular thing results after a time in close breeding and that this reduces the vigor.

Most of our early corn breeders assumed that a moderately large ear with a deep kernel and a well-filled butt and tip was fundamental to yielding power. They selected for this one

thing above everything else in developing our modern types of corn. In all probability, the pioneer corn breeders, by following this method, brought about a slight increase in the yielding power of the corn which they had received from the Indians. It has been found, however, by repeated experiments during the past twenty years that in our modern Corn Belt varieties, no ear character is so very closely associated with yield. At the Ohio station, the growers selected for shallow-grained corn year after year for a number of years, but the yield of shelled corn per acre was not impaired thereby. Seed from ears with bare tips seems to yield just as well as seed from ears with well-filled tips. By selection, it is possible to develop corn of beautiful appearance, but it seems to be very difficult to develop corn of outstanding yielding power. So far as we know now, very few of the stalk or ear characteristics which we can see with the eye are at all closely related to yield in our ordinary varieties of Corn Belt corn. It is obvious, of course, that, in the case of a corn which is too late for the season, one of the things which must be done is to pick for a smaller ear and stalk, and vice versa. But in the case of a well-acclimated strain no method of selection has yet been found which has so very much effect on yielding power. It has been found possible to alter the appearance of the ear and stalk considerably, but the improvement of the yielding power by any method of selection has been found to be very difficult.

Breeding Methods

Ear-row breeding.—In the closing years of the nineteenth century and the opening years of the twentieth, the Illinois and Ohio stations developed the "ear-row" method of corn breeding. The theory of this method seemed so sound that every one had great hope that the inherent yielding power of corn subjected to this method of breeding would be greatly increased.

To begin with, fifty or a hundred good ears of a high-yielding

strain were picked out. These were planted an ear to a row, part of the seed from each ear being saved for planting the year following. Each row was weighed up separately in the fall, and it was invariably found that some of the good rows would yield about twice as much as the poor rows, and ten or twenty bushels per acre more than the average of the field. The plan was then to go back to the remnant seed of the fifteen or twenty ears which had produced these high-yielding rows and plant them the following year in a small plot by themselves, an ear to the row. It was supposed that seed saved from this plot would yield much more than the original corn. As a matter of fact, the results were not so very encouraging. This was ascribed to inbreeding, and the method was modified to provide for detasseling of alternate rows and saving seed only from the detasseled plants. Much time and thought was spent on developing fine points in the method. In recent years, very little has been said about the ear-row method because no outstandingly high-yielding strain of corn has been developed by it. Here and there, practical farmers have used the method for a short time, but they have almost always dropped it after a year or two. At the Nebraska station it was found, after fourteen years of continuous ear-row breeding with Hogue Yellow Dent, that the yielding power has been decreased about one-third of a bushel per acre from the regular Hogue handled in the ordinary way. By crossing four of the high-yielding strains isolated by the ear-row method, the yield was increased about 1½ bushels per acre, as an average of seven years' tests. It would seem that scarcely one farmer in a thousand is justified in making any effort to improve his corn by the use of the ear-row method. Even in the hands of expert corn breeders the ear-row method of increasing corn yields has not proved so very satisfactory.

Cross-breeding.—About 1910, a number of the experimental corn breeders became temporarily enthusiastic over the possibilities of improving yielding power by crossing two varieties. By planting two varieties in alternating rows and detasseling

the one, it is easily possible to obtain cross-bred seed to plant the year following. At the Connecticut and Minnesota stations, crosses between a high-yielding flint variety and a high-yielding dent have often been found to yield more than either parent. At the Michigan experiment station, in the late seventies, and at the Illinois experiment station, in 1892, cross-bred seed yielded several bushels more per acre than the higher yielding of the two parents. More recent and complete experiments, however, at the Iowa and Nebraska stations, indicate that very few crosses will yield as well as Reid Yellow Dent in Iowa or Hogue in Nebraska. As a four-year average, the highest yielding cross-bred corn at the Nebraska station was a cross of Reid and Hogue which yielded 45 bushels per acre as compared with 45.2 bushels for pure Hogue and 44.9 bushels for Reid. In one year the cross outyielded the Reid by 9 bushels and the Hogue by 4 bushels, but in the other three years the pure parents had the advantage. Thirteen different crosses at the Nebraska station yielded as a four-year average 1.6 bushels per acre less than the average of their parents. At the Iowa station, the results have been much the same, no cross of varieties consistently outyielding Reid Yellow Dent. The bulk of the evidence indicates that crossing two dent varieties is not ordinarily worth while, but that the crossing of flints and dents may have some possibilities. It seems that the average Corn Belt farmer will not find it worth while to produce cross-bred seed himself, and, unless some new and startling combinations are found, it is very doubtful if it will pay him to buy cross-bred seed from anyone else.

Inbreeding

The newest method of corn breeding is based on developing inbred strains of corn by putting the pollen of a plant on the silk of the same plant and continuing this "selfing" generation after generation until after four or more generations absolutely distinct inbred types have been produced. The inbreds as

usually developed by this method yield about 20 bushels per acre under the same conditions that ordinary corn yields 50 bushels. When two unrelated inbreds are crossed, however,

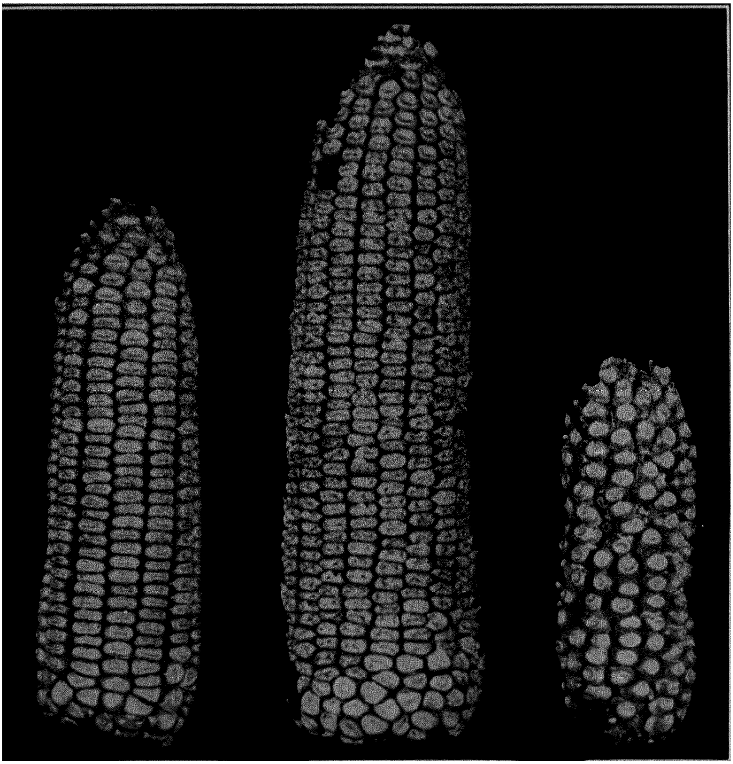


FIG. 73.—On the left an inbred, which was developed after five years of selfing. On the right inbred No. 1–6 of the Connecticut Station, which has been selfed for seventeen years. In the center the cross of the two, which is a vigorous, productive type, producing more than Reid corn and twice as much as either inbred parent.

startling results usually follow. At the Nebraska station, where all other methods of corn breeding have failed to produce a higher yield than Hogue Yellow Dent, as grown in the ordinary

way, it was found, as a four-year average, that the cross of eight sets of two inbreds each yielded 48 bushels, as compared to 41 bushels for the Hogue in the same years. Occasionally two inbreds do not " nick " well, and yield only half as much per acre as the variety from which they were derived. On examination, it will generally be found that inbreds producing such results are either closely related, or have some serious weakness in common, or are weaker than the average inbred. At the Connecticut station, where corn has been inbred for a greater number of generations than anywhere else in the world, it has been found that, while crosses of two inbreds have often yielded more than the original variety, even higher yields were obtained by crossing four inbreds together to produce a " double cross." This takes two years. For instance, if A, B, C and D are the inbreds, the method is to produce single crosses, AB and CD, the first year and then cross these the following year to produce double cross ABCD. This double-crossed ABCD seed, when planted, has given exceptionally good results at the Connecticut station. The single-crossed seeds produce plants and ears which are very uniform, every plant and ear looking almost exactly like every other plant and ear. The double-crossed seeds, however, produce plants and ears which vary from one another about as much as is the case in the ordinary variety. This variability may account in some measure for the double-crossed seed yielding more than the single-crossed.

Practical method for farmers.—What the final practical outcome will be of this new theory of producing inbred strains and then combining them into single, double or even quadruple crosses, no one can say. The method looks promising, but there are some drawbacks. The cross must be made every year. Seed selected from a high-yielding single cross is very disappointing in its ability to yield the next generation. It promptly lapses back toward its inbred form, and usually yields only about three-fourths as well as the year before.

Growers of hybrid corn should not pick seed for it is necessary with this kind of corn **for them to buy their seed**

every year from seedsmen or seed associations which are specializing on this kind of thing. However, it may be that further experimenting will demonstrate that it will be possible after forty or fifty good inbreds have been located which are mutually compatible to combine them together in the form of a new variety, with the result that the yielding power of this complex cross will not slide downhill in later years in the same way as a single

FIG. 74.—Inbred *A* on right was crossed with inbred *B* on left. The *AB* crossed seed when planted gave the strong, vigorous stalks in center which are much more productive than either inbred parent.

cross or a double cross. Just what the application of breeding and cross-breeding inbred strains will be, no one can say with any certainty. It does seem to be plain, however, that this method offers the best hope of making any genuine progress in corn breeding. It is estimated that farmers grew about 500,000 acres of hybrid corn in 1936. In a few years hybrid corn will be planted on several million acres annually.

From time to time, all progressive corn growers should try out corn which has done well in corn-yield contests and also single and double crosses of inbreds which may be offered by experiment stations and seed companies as time goes on. Of course, growers not interested in hybrid corn should continue to save seed as outlined in Chapter I.

It is interesting to note in the Iowa corn-yield contests, beginning in 1924, that crosses of inbreds have consistently outyielded the open pollinated sorts. The lead of the best hybrids has been 5 to 10 bushels per acre over the regular Reid strains. If further experiments continue to prove that crossed inbreds have such an advantage it will pay to go to considerable pains to produce such seed. A bushel of corn will plant seven acres, and if the increased yield per acre is only 4 bushels it will be seen that with corn at 70 cents a bushel, seed of the right kind of crossed inbreds may be worth $20 a bushel more than ordinary seed corn.

Nearly every experiment station in the Corn Belt is producing inbred strains of corn and trying to determine just which ones combine to produce the highest yield. The best inbreds for crossing purposes will eventually be distributed by some of the state stations. The problem then will be to get these inbreds into the hands of reliable, well-trained people experienced in producing seed corn, who can be relied upon to do a good job of crossing the inbreds so that farmers who buy will know just what they are getting. State certifications may be necessary.

Technique of Inbreeding

Inbreeding involves placing live pollen of a plant on the silks of the same plant and also keeping out any foreign pollen. The customary way of doing this is to tie a 12-pound pinch bottom paper sack over the tassel just before it begins to shed pollen. A 3-pound paper sack or a glacine bag (2½ by 5 inches is

a convenient size) is slipped over the ear shoot as soon as it is out far enough so as to hold the bag on, and before any silks have appeared. Thump the tassel bag to tell when the pollen has started to shed. If the silks are out and pollen is shedding, take the tassel sack off and invert it over the ear shoot and tie it, allowing the bag to bend in the middle while tying so as to avoid losing the pollen. After the tying is completed, straighten out the bag and shake it suddenly, so that a considerable amount of the pollen in the bag will fall on the silks enclosed in the bag. Paper clips may be used instead of string to hold the sacks in place over the young ear shoots. The sack is folded once or twice behind the ear shoot and one paper clip suffices to hold the sack in place.

FIG. 75.—Illustrating hand pollination of corn when bottles are not used.

New method.—In 1922, a technique of inbreeding known as the bottle method was devised by Merle T. Jenkins, of the United States Department of Agriculture. It has never been generally accepted by corn breeders as worth the additional trouble it requires. With the bottle method, the ear shoots are covered up in just the same way as with the old-fashioned method, but the tassels are not covered at all. When the silks are out and the tassel has begun to shed, the tassel is pulled out

and put in a 12-pound pinch-bottom paper sack and the base of the tassel is placed in a 1- or 2-ounce bottle filled with water and tied to the corn stalk at the same place as the ear shoot comes out. The paper sack encloses both the ear shoot and tassel and is held in place by a paper clip or a string. The silks of the shoot

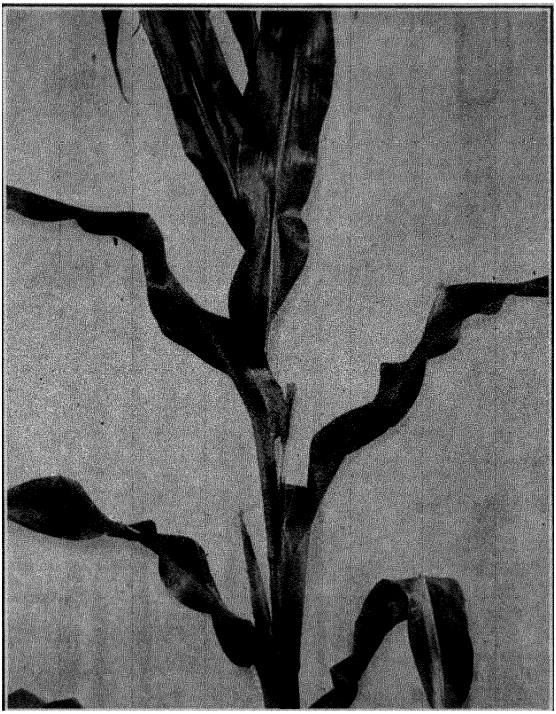


FIG. 76.—Paper sack keeps foreign pollen from getting on silks.

are cut back together with the tips of the husks for an inch, or even 2 inches, just before the 12-pound sack with its enclosed tassel is put over it. A day or two later the silks grow out again and the water in the little bottle has kept the tassel alive so that it is still ready to furnish pollen when the silks are ready again. The bottle is most quickly attached to the

stalk by means of rather heavy copper wire of about No. 16 gage, one end of which is twisted around the neck of the bottle. The wire is pulled down between the ear shoot and the stalk, and it will be found that the pressure of the base of the ear shoot against the stalk will be sufficient to hold the wire with the

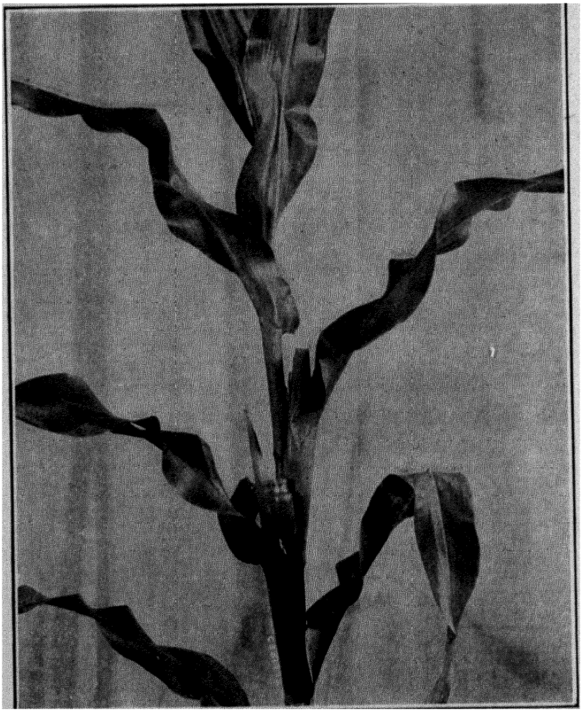


FIG. 77.—Cutting off the silk and putting bottle in place.

bottle attached to it. The bottles are carried to the field in a water bucket. The bottle method appears to be more difficult and complicated than the old-fashioned way, but in actual practice is much more rapid. Two men can inbreed forty to sixty plants an hour. One very great additional advantage is that rain often drove water into the tassel bags used in the old-

fashioned method, making it necessary to do a lot of work in replacing them, and sometimes making it impossible to inbreed certain plants at all.

Growth of tassels and silks.—Following are some facts about the flowering habits of our typical Corn Belt stalk of

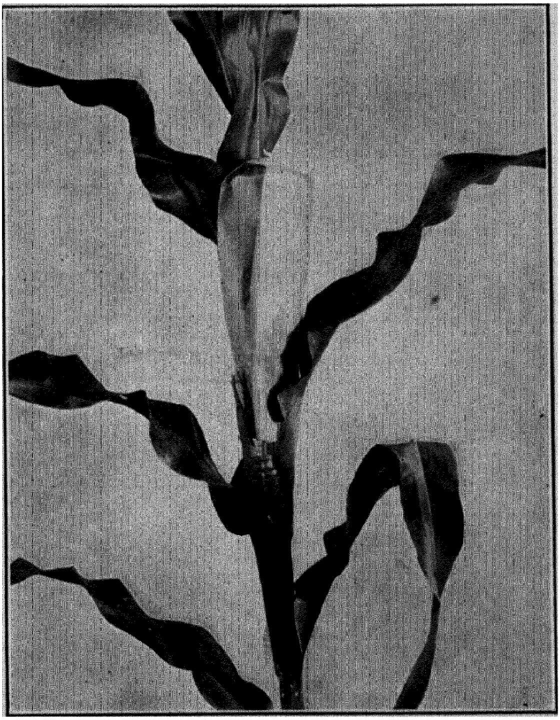


FIG. 78.—Tassel is put in bottle and both the tassel and the ear shoot with silks cut back are covered with paper sack.

corn, which may be worth while to anyone who is expecting to do some inbreeding:

1. From the time the tassel first appears until the first pollen is shed is usually about a week.

2. Silks usually appear two or three days after pollen shedding first

begins, although there are occasional plants whose silks come out a day or two in advance of the pollen.

3. Pollen shedding continues for about a week, although a few plants produce tassels which will continue to shed for ten or twelve days.

4. With a moist atmosphere and a rather low temperature, corn pollen may live two or three days, but with temperature and humidity as it usually is in the ordinary corn field, nearly all of the pollen dies within twenty-four hours after it leaves the tassel.

5. Silks are receptive to pollen for two weeks or even longer after they first appear. If they are not fertilized, they may grow to a length of 10 or 12 inches, although in the case of some plants the unfertilized silks make very little more growth than the fertilized. After a pollen grain falls on a silk, it grows with great rapidity, germinating and sending a pollen tube through 7 or 8 inches of silk to the ovule (unfertilized corn kernel) within twenty-four hours.

6. If a tassel is pulled before it begins to shed pollen, it will rarely live to shed, even though it is placed in water. However, after a tassel has begun to shed it may be pulled and continue to produce viable pollen for a day, even though it is not placed in water.

7. There is considerable difference in the habits of different corn plants, but the typical plant acts about as described in the foregoing.

Heredity in Corn

In corn, as in other plants and in animals, the hereditary characteristics are carried over from one generation to the next in the male and female germ cells. The male germ cells are the pollen grains and the female germ cells are the unfertilized ovules or kernels found at the base of the silks. Each male germ cell or pollen grain contains ten chromosomes and so does each female germ cell. The chromosomes are the parts of the germ cells which carry the hereditary material. One chromosome, for instance, may carry the factor which makes the kernels sweet, whereas another in the same pollen grain may carry a factor which makes the kernels yellow in color.

To make a fertilized corn kernel, a pollen grain with its ten chromosomes must fall on the silk of a corn plant and then grow down the silk into the ovule, where the ten chromosomes of the pollen grain unite with the ten chromosomes of the ovule. The corn embryo, therefore, and the plant which grows from it,

contains twenty chromosomes. Only the germ cells contain ten. About three or four weeks before corn comes into tassel, what might be called the pre-germ cell material still contains twenty chromosomes. At this time the pre-germ cell material gets ready to form real germ cells with ten instead of twenty chromosomes. This process is known as the reduction division.

Xenia.—When yellow corn pollen fertilizes a white corn ovule, the kernel which develops is light yellow in color. When the reverse takes place, and white corn pollen fertilizes a yellow corn ovule, the kernel which develops is almost as yellow in color as though the fertilizing had been done by yellow corn pollen. When white or yellow corn ovules, however, are fertilized by red corn pollen, the resulting kernels are white or yellow, just as though white or yellow pollen had been used.

The immediate effect which corn pollen has on the corn kernel which develops immediately after fertilization is known as xenia. The corn germ cells contain nuclei other than those which form the embryo. The male germ cells or pollen grains have one of these additional nuclei and the female germ cells have two. In fertilization, this one additional nucleus of the pollen grain joins with the two extra nuclei of the ovule, and this combination governs in large measure the development of that part of the corn kernel which is outside of the germ and under the hull. Because it is formed by three nuclei this material contains thirty chromosomes. The hull is a part of the mother plant, and it is impossible for the pollen grain to affect its color. Red color in corn is usually found in the hull, and that is the reason red pollen has no immediate effect on the color of white or yellow corn. Red corn can grow alongside white corn and no results will be seen that year, but the year following, if the white corn is saved for seed, there will be some plants producing red ears.

The fact that the ovule has two extra nuclei and the pollen grain only one explains why white corn pollen has a slightly different effect on a yellow ovule than yellow corn pollen has on a white ovule. The yellow color is found in the horny starch

of the kernel and is therefore governed right away in its development by the combination of the one extra nucleus of the pollen grain with the two extra nuclei of the ovule. When there are two doses of white to one of yellow, it is to be expected that the color should be a little paler than when there are two doses of yellow to one of white.

Sweetness of the corn kernel, being in the endosperm, is governed by xenia, although no one has proved that it makes any difference which way the fertilization takes place. If sweet ovules are fertilized by ordinary pollen, the kernels seem to be just as starchy as though the ordinary corn ovules were fertilized with sweet pollen.

Just under the hull, as will be noted on page 191, of Chapter XIII is the aleurone layer, which is susceptible to xenia. The most common xenia effect in the aleurone is a blue color, the heredity of which is very complex. Generally speaking, when blue corn pollen fertilizes white or yellow corn ovules, the result is kernels blue in color.

Briefly, it may be said that the common xenia effects in corn are with the following pairs of characters, the dominant being named first:

Blue color versus no color in the aleurone.
Yellow color versus no color in the horny starch.
Starchy corn kernel versus sweet corn kernel.

Red color is never a xenia effect except in the case of a very rare and dull kind of red, which acts in the same way as blue, manifesting its color through the aleurone.

Mendelian characters.—Most of the work on heredity in corn has centered around the problem of finding which characters are Mendelian dominants and which Mendelian recessives. More than 350 Mendelian characters have already been discovered. Many of these characters are freaks which so affect the plant that it does not have the capacity of producing an ear which a farmer would save for seed. In spite of this,

they are found to some extent in nearly all corn-fields. They seem especially likely to be found in rather large numbers on those farms where a special effort has been made to breed a high-yielding strain of corn by the ear-row method. One of the commonest of freaks is a white stripe running through the leaves. A plant of this sort when inbred and the seed planted produces plants all of which are affected with striped leaves. But if the silks of a striped-leaved plant are fertilized with pollen from a normal plant, and the seeds produced are planted, the result will usually be plants all of which are normal. Occasionally, a plant which appears normal carries the striped character in one-half of its pollen grains, and when the pollen of such a normal plant is used on the silks of the striped plant the result will be plants one-half of which carry striped leaves and one-half of which are normal. Normal plants which are produced in this way bear pollen one-half of which carries the striped-leaf factor and one-half of which are normal. Also, one-half the ovules or unfertilized corn kernels carry the striped-leaf factor and will produce a striped-leaf plant if striped-leaf pollen falls on their silks. The striped-leaf character is known as a Mendelian recessive, and normal leaf color is the Mendelian dominant.

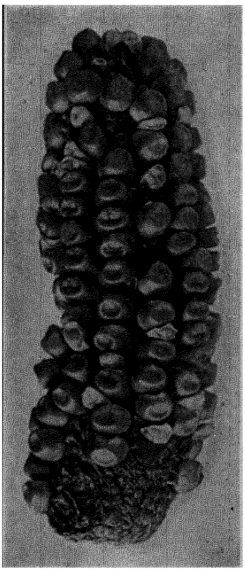
Following are some of the Mendelian recessives, affecting the plant or leaf:

1. Blotched or mottled leaf.
2. Pale green leaf color.
3. Yellow leaf color.
4. Pure white seedlings.
5. Crinkly leaf.
6. Short jointed or the brachytic type of dwarf corn.
7. Crooked jointed or zigzag corn.
8. Tassels with no pollen.
9. Leaves with a mid-rib but no real leaf.

Nearly all abnormalities, and there are hundreds of them, are Mendelian recessives. Some of the outstanding exceptions in the way of unusual characters which are Mendelian dominants are:

1. Purple plant color (governed by three dominant factors, A, B, Pl).
2. Brown plant color (determined by dominant B and dominant Pl with recessive a).
3. Pod corn or primitive corn with a husk covering each kernel.
4. Red kernels which owe their color to the red pericarp or hull.

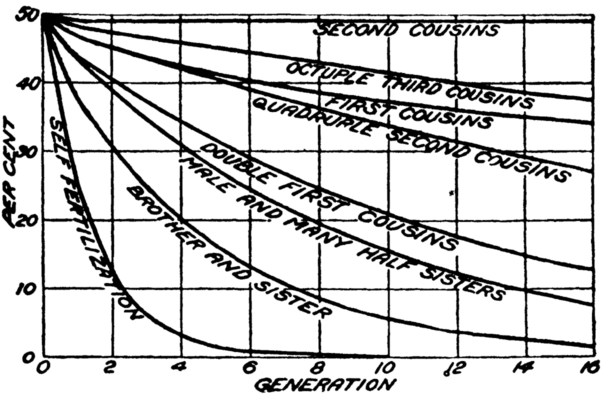
Heterozygosity and how inbreeding affects it.—A plant or animal is said to be homozygous when all of its germ cells carry the same hereditary properties. Most corn plants are not homozygous, but are heterozygous (germ cells differ from one another). However, there are varying degrees of heterozygosity. For illustration, we may say that a completely homozygous corn plant produces germ cells each of which carries the inheritance ABCDEFGHIJ. A slightly heterozygous corn plant might carry half its germ cells with aBCDEFGHIJ and the other half with ABCDEFGHIJ. Actually, the ordinary corn plant carries dozens of different types of germ cells, as may be roughly illustrated in part as follows: ABCDEfghij; ABcdeFGhij; ABcdEfgHiJ; ABCdefghij; ABcDeFgHiJ, etc., etc. Perhaps this particular plant may be homozygous for A and B and heterozygous for all else. In the ordinary cornfield, it may be roughly assumed that the average plant is homozygous for about half of its characters and heterozygous for half. As long as wind pollination continues, and the farmer does not linebreed by planting closely related ears, there will be little or no change in the proportion of homozygosity and heterozygosity. If, however, a plant which is 50 per cent heterozygous



Courtesy of Connecticut Experiment Station.

FIG. 79.—Illustrating defective kernels. A Mendelian recessive.

is selfed, the next generation will bear germ cells which are much alike, and the probabilities favor only 25 per cent heterozygosity. In succeeding generations, the heterozygosity should decline to the following percentages: Second, 12.5 per cent; third, 6.25 per cent; fourth, 3.12 per cent; fifth, 1.56 per cent, etc. After five generations of selfing, it is a general rule that almost complete homozygosity is reached, provided the plant to start with was 50 per cent homozygous. It takes about



Bulletin 1121, United States Department of Agriculture.

FIG. 80.—Illustrating how a blood strain which is 50 per cent heterozygous is affected by different numbers of generations of different methods of breeding. Six generations of selfing should bring 99.2 per cent homozygosity if the strain was 50 per cent homozygous to start with.

seventeen generations of brother and sister mating to give the same degree of homozygosity as five generations of selfing.

Theory of hybrid vigor.—It is theoretically possible but not very probable some day to find an inbred strain which is homozygous only for good qualities and which would therefore be vigorous. Actually, all inbred strains so far developed by selfing for four or more years are decidedly unproductive. When two different homozygous inbreds are crossed, the result is usually great vigor. This kind of vigor is supposed to be

due to the fact that most good characters are Mendelian dominants and most bad ones are Mendelian recessives, and that the first generation cross of two strains gives a chance for all of the good characters of both parents to appear, with none of the bad, unless the bad are found in both parents. It is this theoretically sound background which has caused so many experimenters to spend much time with corn inbreeding work in recent years. Hybrid vigor is explained in the 1936 Yearbook of the United States Department of Agriculture as follows:

> The phenomenon had been noticed for over a century by plant breeders and probably for at least 2000 years by animal breeders. The early explanation of the increased vigor of the first-generation hybrids assumed that it was due to the physiological stimulation resulting from the mixing of unlike protoplasm from the egg and sperm. The reduction in vigor with inbreeding was assumed to be due to the disappearance of this stimulation as the strains automatically became pure or homozygous.
>
> In 1910, Bruce, on the basis of purely mathematical considerations, suggested that hybrid vigor might be explained on the basis of the complementary action of favorable dominant growth factors.
>
> Keeble and Pellew in 1910 reported the results of their experiments with peas, which added considerable evidence to support this explanation. They crossed two strains of peas, each 5 to 6 feet tall. One strain had thick stems with many short internodes and the other thin stems and long internodes but fewer of them. The hybrid was 7 to 8 feet in height. In it the characteristic of thick stems with many internodes from one parent was combined with the characteristic of long internodes from the other. The next generation showed segregation into four classes, one class containing plants as tall as the hybrid, two classes containing plants like the two parents, and the fourth class containing dwarf plants which combined the short internodes of one parent with the thin stems and few internodes of the other.
>
> Two serious objections to the complementary action of favorable dominant genes prevented the general acceptance of this explanation of hybrid vigor. If this explanation were correct, then, according to theory, it should be possible with inbreeding to obtain homozygous lines containing the dominant factors contributed by each parent, comparable to the segregates obtained by Keeble and Pellew which had many and long internodes. These lines should be as vigorous as the hybrid and should breed true for their vigor. No such lines of corn have been obtained.

Also, as pointed out by Emerson and East, the progeny from crosses exhibiting hybrid vigor should show an unsymmetrical distribution rather than the apparently normal distributions obtained from them.

The suggestion by Jones in 1917 that linkage between the favorable dominant growth factors would account for the failure to meet these two theoretical requirements removed them as objections to this explanation of hybrid vigor and led to its general acceptance. G. N. Collins later has shown that the assumption of linkage probably is unnecessary.

Critical experiments to determine the relative influence of physiological stimulation and of dominant genes in producing hybrid vigor have been extremely difficult to devise. The recent studies of F. D. Richey on convergent improvement seem to offer the best means yet suggested. Richey has suggested a procedure of crossing two lines, backcrossing to each parent through several generations while selecting for the characteristics of the other parent, selfing to fix the factors held by selection, and repeating the process using the improved lines in order to concentrate or "converge" the favorable genes from the two parent lines into a single line.

If hybrid vigor is due entirely to the action of the dominant genes, these "converged" or recovered lines should be as vigorous as the hybrid between the two parents. If physiological stimulation plays an important rôle in producing the vigor of hybrids, the recovered lines would be expected to be less vigorous than the hybrid. Incidentally, the method offers much promise as a procedure for improving existing inbred lines.

Mutations.—Men who have inbred corn for six or more generations find that a great many strains are not 99 or more per cent homozygous. In many there is far more variability than would theoretically be expected. Sometimes, after a strain has been reduced to uniformity, it will suddenly begin producing freaks of one sort or another. In some plants, as in the jimson weed, for example, it has been discovered by careful study that occasionally plants will be produced with twice the normal number of chromosomes. Unquestionably the germ cells of a strain of corn which has been purified by inbreeding will occasionally mutate, which means that one or more chromosomes of a few of the cells will begin to act in a

slightly different way. Some inbred strains of corn never seem to mutate, whereas others are quite susceptible.

What corn heredity means to the practical farmer.—In the present state of our knowledge, corn heredity does not mean so very much to the practical farmer. It is worth while for corn farmers to realize, however, that every corn kernel is as definitely the result of a male and female mating as is a cow. With good livestock the farmer knows both the sire and dam. With corn, however, he selects seed on the appearance of the dam only. That is the reason that beautiful show ears do not reproduce themselves. Half the kernels on the show ear may have scrub sires. The breeder who controls only the dam half of the mating is certain to make very slow progress. But at the present time the practical farmer is not warranted in taking any pains to control the pollen with which his seed-corn kernels are to be fertilized. Methods of corn breeding are described earlier in this chapter.

Sometimes breeders of yellow corn are troubled with their corn showing some very pale yellow or even white kernels. Is it difficult to get rid of the contamination? White color is recessive to yellow, and contamination will remain a long while, although it can gradually be reduced if only deep yellow ears are planted for a number of years.

When white corn is contaminated with yellow corn, the problem is simpler. Theoretically, if only pure white kernels are planted, the yellow contamination can be completely gotten rid of in one year. Actually, a few light yellow kernels are usually allowed to slip through. The problem of freeing white corn from yellow contamination is really quite simple, however.

Sweet corn contaminated with field corn is the same kind of a proposition as white corn mixed with yellow corn. If only sweet corn kernels are planted, the only chance for field corn contamination is from pollen which blows in that season. All the plants should be pure sweet corn plants.

When field corn is contaminated with sweet corn, it is an

almost impossible job to get it completely out, although if only field corn kernels are planted, there will probably be, after three or four years, not more than one contaminated ear to ten acres.

If red corn is grown alongside white or yellow corn, there will be a number of kernels along the edge of the field fertilized with red pollen, although they will not show it because there is no xenia effect with red pollen. The next year every white or yellow kernel fertilized by red pollen will produce a plant bearing a red ear, and these plants will scatter their pollen over the field. Half of these pollen grains borne by such plants will carry the red color factor, but it will be impossible to know which ears have had a few of their kernels contaminated. All that can be done practically is to plant only ears which are not red. But no matter how long this is kept up, there will almost certainly be a few red ears produced year after year.

Farmers who are interested in yield rather than appearance of their corn do not care a particle about a slight contamination of their corn with other colors or with sweet corn. But they are interested if their corn blows down badly or if it produces large numbers of white seedlings or other abnormalities which yield poorly. Sometimes farmers who are taking special pains with their corn-breeding work find that the abnormalities are increasing. If the situation gets serious, and there is more than one abnormal plant in every hundred, it may be wise to get an entirely new start of seed. Ordinarily, however, all that is needed is to plant seed only from strong, normal plants. By doing this, it is never possible to get completely rid of abnormalities, but it should be possible to keep them from getting really serious. So far as is known at this writing, the only way of producing a field practically free from abnormal plants is by the method of crossing proved inbred strains. Practical farmers now find it worth while to use crossed inbred seed for general planting.

Linkage.—An advanced step in corn heredity is the study of linkage, discovering which Mendelian factors are located in

the same chromosome. Corn has ten chromosomes, and at this time the inheritance of about 350 genes is known. About 100 of these genes are fairly definitely located on the 10 chromosomes. This kind of work belongs to the professional geneticist at the present. Eventually, it will have very practical applications because after the freakish factors are definitely located in their various chromosomes it may be possible to locate the position of some of the factors which make for yield. In the meantime, it is worth while to know that this kind of work is going on and to be prepared to learn more about it when it finally begins to have some practical applications.

In addition to the study of linkage, other advanced genetic studies looking forward to strengthening the position of hybrid corn as the most outstanding example of the application of genetic research to crop or livestock production have been made. Although there are excellent hybrids far superior to any varieties of corn not only in productivity but also in important characteristics of quality and disease resistance, it is felt that still greater advancements will be made in the near future.

Right now geneticists are utilizing methods other than linkage studies to locate genes on corn chromosomes. They are studying translocations of chromosome material of different pairs of chromosomes. They are utilizing X rays, radium, and ultra-violet light to produce artificial mutations; although no mutations of any practical value have been developed, this work has advanced greatly the knowledge of both the genes and chromosomes in corn. They have applied heat to young ears of corn in the early stages of development and in this way have been able to change the chromosome numbers of corn, particularly the doubling and quadrupling chromosome numbers. As these fundamental cytogenetic studies increase and advance, it is not unlikely that corn-breeding work will become more technical and stay in the hands of advanced students of this crop.

The following list of genes in corn by linkage groups is from Cornell Memoir 180, "A Summary of Linkage Studies in Maize," by Emerson, Beadle and Fraser.

Linkage Group 1

Fourteen genes and four translocations known to be involved in linkage group 1 are listed below:

ad_1	Adherent–1
an_1	Anther ear–1
as	Asynaptic
bm_2	Brown midrib–2
br	Brachytic
f_1	Fine stripe–1
gl_{10}	Glossy seedling–10
gs_1	Green-striped–1
ms_{17}	Male sterile–17
P	Pericarp and cob color
sr	Striate
T 1–2a	Translocation 1–2a (Semisterile–1)
T 1–6a	Translocation 1–6a (Semisterile–5)
T 1–6b	Translocation 1–6b (Low sterile)
T 1–7a	Translocation 1–7a (Semisterile–3)
ts_2	Tassel seed–2
zg_2	Zigzag culm–2
zl	Zygotic lethal

Linkage Group 2

Eleven genes and two translocations known to be in group 2 are as follows:

B	Plant-color booster
ba_2	Barren stalk–2
d_5	Dwarf–5
fl_1	Floury endosperm–1
gl_2	Glossy seedling–2
gs_2	Green-striped–2
lg_1	Liguleless leaf–1
sk	Silkless
T 1–2a	Translocation 1–2a (Semisterile–1)
T 2–5a	Translocation 2–5a (Semisterile–4)
ts_1	Tassel seed–1

v_4	Virescent seedling-4
ws_3	White sheath-3

Linkage Group 3

Fifteen genes are known to belong to linkage group 3, as follows:

a_1	Aleurone, pericarp, and plant color
ba_1	Barren stalk-1
cr_1	Crinkly leaf-1
d_1	Dwarf-1
d_2	Dwarf-2
lg_2	Liguleless leaf-2
ms_3	Male sterile-3
na_1	Nana-1
pg_2	Pale green seedling-2
pm	Pale midrib
ra_2	Ramosa ear-2
Rg	Ragged leaf
rt	Rootless
ts_4	Tassel seed-4
yt	Yellow top

Linkage Group 4

The following seventeen genes are known to belong to linkage group 4:

de_1	Defective endosperm-1
de_{16}	Defective endosperm-16 (de_{su} of Wentz)
Ga	Gamete—differential fertilization
gl_3	Glossy seedling-3
j_2	Japonica-2
la	Lazy plant
lo	Lethal ovule
S_1	Colored scutellum-1
sp	Small pollen (*va* of Singleton, 1932)
st	Sticky chromosome
su_1	Sugary endosperm-1
Ts_5	Tassel seed-5
Tu	Tunicate ear
v_8	Virescent seedling-8
vp_3	Vivipary-3
w_4	White seedling-4
wl	White leaf base

LINKAGE GROUP 5

The following twenty-two genes and three translocations have been reported as belonging in linkage group 5:

a_2	Plant and aleurone color
bm_1	Brown midrib–1
bt_1	Brittle endosperm–1
bv	Brevis
cb	Chloroblotch
Ch	Chocolate pericarp
d_6	Dwarf–6
gl_8	Glossy seedling–8
oy	Oil yellow
pr_1	Red aleurone–1
re_1	Reduced endosperm–1
re_2	Reduced endosperm–2
sc_1	Scarred endosperm–1
sf	Stiff leaves
T 2–5a	Translocation 2–5a (Semisterile–4)
T 4–5a	Translocation 4–5a
T 5–7c	Translocation 5–7c
tn	Tinged plant
v_2	Virescent seedling–2
v_3	Virescent seedling–3
v_{12}	Virescent seedling–12
vp_2	Vivipary–2
Y_2	Yellow endosperm–2
yg_1	Yellow green–1
ys_1	Yellow stripe–1

LINKAGE GROUP 6

The following seventeen genes and three translocations are known to be in linkage group 6:

Bh	Blotched aleurone
fi	Fine-streaked (discarded)
gm_4	Germless–4
ms_1	Male sterile–1
Pl	Purple plant color
po	Polymitotic
py	Pigmy
si_1	Silky ear–1
sm	Salmon silk

su_2	Sugary endosperm–2
T 1–6a	Translocation 1–6a (Semisterile–5)
T 1–6b	Translocation 1–6b (Low sterile)
T 6–9a	Translocation 6–9a
v_6	Virescent seedling–6
v_7	Virescent seedling–7
w_1	White seedling–1
w_5	White seedling–5
w_6	White seedling–6
Y_1	Yellow endosperm–1
yd	Yellow dwarf

Linkage Group 7

Seventeen genes and two translocations are reported to belong to linkage group 7, as follows:

bd	Branched silkless
Bn_1	Brown aleurone–1
fr_1	Frayed–1
fr_2	Frayed–2
gl_1	Glossy seedling–1
Hs	Hairy sheath
ij	Iojap striping
in	Intensifier of aleurone color
o_2	Opaque endosperm–2
pg_3	Pale green seedling–3
ra_1	Ramosa ear–1
sl	Slashed
T 1–7a	Translocation 1–7a (Semisterile–3)
T 5–7a	Translocation 5–7a (Semisterile–6)
Tp	Teopod
v_5	Virescent seedling–5
va_1	Variable sterile–1
Wh	White endosperm
Yp	Pale yellow endosperm

Linkage Group 8

For linkage group 8 only two genes and one translocation have been reported, as follows:

j_1	Japonica–1
ms_8	Male sterile–8
T 8–9a	Translocation 8–9a (Semisterile–2)

LINKAGE GROUP 9

Twenty-eight genes and two translocations are known to belong to linkage group 9, as follows:

ar	Argentia
au_1	Aurea-1
bp	Brown pericarp
C	Aleurone color
cr_2	Crinkly leaf-2
d_3	Dwarf-3
da_1	Dilute aleurone-1
Da_2	Dilute aleurone-2
de_{15}	Defective endosperm-15
g_4	Golden-4
gm_e	Germless-e (gm_1 of Eyster, 1929)
I	Inhibitor of aleurone color
l_6	Luteus-6
l_7	Luteus-7 (au_2 of Eyster, 1929)
ms_2	Male sterile-2
ms_{20}	Male sterile-20
pk	Polkadot leaves
Pr_2	Purple aleurone-2
re_3	Reduced endosperm-3
sa_1	Striped auricle-1
sc_2	Scarred endosperm-2
sh	Shrunken endosperm
su_3	Sugary endosperm-3
T 6–9a	Translocation 6–9a
T 8–9a	Translocation 8–9a (Semisterile-2)
v_1	Virescent seedling-1
v_{15}	Virescent seedling-15
w_{11}	White seedling-11
wx	Waxy endosperm
yg_2	Yellow green-2 (v_{14} of Phipps, 1929)

LINKAGE GROUP 10

The following twenty-two genes have been shown to belong to linkage group 10:

a_3	Anthocyanin color-3
d_7	Dwarf-7

de_f	Flint defective
du	Dull endosperm
f_3	Fine stripe–3
g_1	Golden–1
gm_2	Germless–2
l_1	Luteus–1
l_2	Luteus–2
l_4	Luteus–4
li	Lineate
nl_1	Narrow leaf–1
Pc_2	Purple coleorhiza–2
pg_1	Pale green seedling–1
R	Colored aleurone and plant
Rp	Rust resistance (Puccinia)
v_{18}	Virescent seedling–18
v_{20}	Virescent seedling–20
vp_1	Vivipary–1
w_2	White seedling–2
xn_1	Xantha seedling–1
zb_5	Zebra-striped–5

SELECTED LIST OF REFERENCES

RICHEY, F. D. Corn Breeding. U. S. D. A. Dept. Bul. 1489. 1927.

HAYES, H. K., JOHNSON, I. J., and CRIM, R. F. Double-crosses of Corn for Distribution in Minnesota. Minn. Bul. 275. 1931.

RICHEY, F. D., and SPRAGUE, G. F. Experiments on Hybrid Vigor and Convergent Improvement in Corn. U. S. D. A. Tech. Bul. 267. 1931.

EMERSON, R. A. The Present Status of Maize Genetics. Proc. 6th Int. Cong. Genetics. Vol. 1. Pp. 141-52. 1932.

EMERSON, R. A., BEADLE, G. W., and FRASER, A. C. A Summary of Linkage Studies in Maize. Cornell Memoir 180. 1935.

RICHEY, F. D. The What and How of Hybrid Corn. U. S. D. A. Farmers' Bul. 1744. 1935.

JENKINS, M. T. Corn Improvement. U. S. D. A. 1936 Yearbook of Agriculture. Pp. 455-522. 1936.

CHAPTER XVII

JUDGING AND TESTING FOR YIELDING ABILITY

CORN shows first became really popular about 1890, reaching their crest about 1910. In the early corn shows, the idea was to give the prize to the sample which gave indications of the greatest yielding power. The men who drew up the early score cards assumed that of course high yield was associated with ears as large as the ordinary season would mature, and ears with a high percentage of shelled corn. Therefore, in the central part of the Corn Belt the ideal was an ear 10 inches long, $7\frac{1}{2}$ inches in circumference, with eighteen to twenty-two rows packed together tightly on the cob and carried out over the tip and well-rounded butt. The space between the rows of kernels, both at the cob and on the outside of the ear, was to be as narrow as possible because that meant a higher percentage of shelled corn. Deep kernels, keystone in shape, and moderately wide, met the ideals better than either the narrow shoe-peg kernel or the shallow, extremely square kernel, both of which were thought to be associated with a lower shelling percentage. Ears with straight rows and cylindrical in shape were preferred because the kernels were more uniform and could be planted with fewer skips by the corn planter. Large germs were desired because that meant more oil and protein in the kernel and therefore more feeding value. For probably fifty years before the popular corn shows of the early twentieth century, these common-sense points had appealed to thoughtful corn farmers everywhere, and the men who made out the score cards in the nineties merely reflected the opinions of the men who had thought most about corn.

Corn Judging Development

Fancy points.—About 1900, the corn judges began to prefer corn with a rough dent. The rough dented corn seemed to have straighter rows and more uniform kernels, which also seemed to be a little deeper. It was also advisable to develop fancy points of this sort in order to enable the judges to make any distinction between the hundreds of competing samples, most of which were almost equally good from the standpoint of the original score card. And so it came about that corn judges unconsciously came to think more and more about fancy points.

Tests upset ideals.—The first corn shows were held before the days of careful experimental work. It is not surprising, therefore, to find that actual yield tests with different types of corn rudely upset some of the most cherished ideals of the early corn judges. For ten years the Ohio station continuously selected for moderately long ears of corn and for moderately short, and contrasted the yielding power of the two strains. The short ears, only 6 or 7 inches in length, seemed to have the ability to yield almost exactly the same as the ears 9 or 10 inches long. Bare tipped ears with nearly an inch of cob showing yielded about the same amount of shelled corn per acre as ears with perfectly filled tips. Ears shelling out only 76 per cent yielded considerably more ear corn per acre and fully as much shelled corn as ears shelling 88 per cent. Smooth corn slightly outyielded the rough corn. Carefully conducted tests of this sort at the Ohio, Nebraska and a number of other stations made it appear extremely doubtful if many of the points on the old-fashioned corn score card were worth while from the standpoint of yield.

No one has as yet learned enough about corn to know just what relationship there is between yield and the different ear and kernel characteristics. The relationship seems to be different in different seasons and on different soils. The following yield score card is based chiefly on experimental work in Iowa

and Illinois and probably applies as well as any to central Iowa and Illinois.

YIELD SCORE CARD

(No fancy points)

	Points
Solid, well-matured ear which weighs like lead (heavy for its size, with kernels firm on cob; no sign of shredded shank attachments at butt)	25
Length of ear (at least 7 inches)	5
Circumference of ear (at least 5.5 inches)	5
Width of kernel (not less than $\frac{1}{4}$ inch wide)	5
Thickness of kernel (not more than 8 kernels to the inch)	5
Depth of kernel (at least $\frac{7}{16}$ inch deep)	5
Kernels plump at tip coming down broad and thick to the cob	15
Kernels without blistering or damage by mice	5
Kernels with bright, large germ (germ should be clear and waxy when cut)	5
Kernels come loose from cob without leaving tip cap or taking part of cob with them—no evidence of disease or discoloration	15
Kernels with slightly rounding sides and medium to wide space between rows at outside of ear	5
Hard, horny kernels free from starch, lustrous, shining and rather smooth	5
Total	100

It is assumed in this score card, as should be the case with all corn score cards, that ears which will not grow are given no consideration whatever. In Illinois and parts of Iowa where root rot diseases are serious, the last point—hard, horny, shiny kernels free from starch—probably should be given 15 to 20 points instead of only 5, for it has been definitely proved that starchy kernels are more susceptible to these diseases and yield less as a consequence. In Nebraska, especially in the western part, 15 or 20 points should be given to a smooth dent combined with a slender ear and freedom from starchiness. On the other hand, the rich bottom lands of central and southern Indiana seem to yield more when planted to a rough, somewhat starchy corn carrying twenty or even twenty-two rows of kernels,

than when planted to the smaller, slender-eared type with its horny, shiny kernels.

What corn judges like.—While no one knows much about measuring the effect of ear and kernel characteristics on yield, it is fairly easy to learn what type of corn will appeal to corn judges at the big corn shows. In the single-ear classes in the central part of the Corn Belt, the ideal ear is 10 inches long, 7½

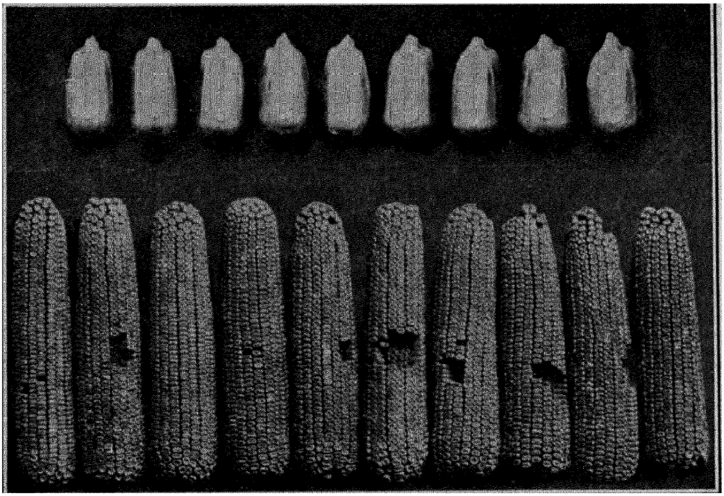


FIG. 81.—This type of ten-ear sample, which represents hundreds of hours of labor picking over thousands of ears of corn, wins at the corn shows. No one can tell in advance whether such corn will yield as much as, or more than, ordinary corn.

inches in circumference, with twenty or twenty-two straight rows of kernels carried out to the tip (tip kernels being of the same type as the kernels on the body of the ear), and with a well-rounded butt with only a small opening left for the shank. Of course, the ear must be straight and cylindrical in shape, with the diameter carried uniformly from the butt to within 2 or 3 inches of the tip, where a slight taper is permissible. The kernels must be moderately wide, keystone in shape, deep,

plump at the tip, and without any trace of being shrunken or blistered. In Iowa and Illinois, the judges lay great emphasis on the backs of the kernels being horny and shiny, but in Indiana and at the International Grain and Hay Show they are not so particular about this point. In central Iowa, Indiana and at the International the custom has been to favor the rough corn, whereas in Illinois, since 1920, they have been favoring the smooth corn with an exceedingly horny kernel, showing the least possible susceptibility to root rot infections. By attending corn shows and associating with corn judges, it is possible to learn their ideals and pick corn to meet them. In the ten-

FIG. 82.—An ear of Johnson County White which sold for $250 at Chicago Corn Show. Such an ear may be no more productive than a very ordinary ear.

ear and bushel classes, it is necessary to pay great attention to uniformity. All of the ears should be within an inch of the same length. None of the ears should carry less than eighteen rows nor more than twenty-two. The kernels should all be of the same size, shape and color, showing no trace of mixture with white pollen (if the variety is yellow) or yellow pollen (if the variety is white). In addition, the ears must be true to what the judges recognize as the variety type. To fulfill all of these requirements means that a man must start with seed from a recognized show strain and grow it out on rich soil and then go over 50,000 or 100,000 ears in the hope of finding a prize-winning sample. Picking corn for show is interesting work which appeals to farmers with an eye for the beautiful. The premiums offered

at the corn shows have made corn exhibiting profitable for many men. This has been especially true in central Indiana and the southern half of Iowa, where a combination of rich soil, a rather long season, and favorable rainfall has made it possible to grow beautiful, rough, large-eared corn very easily. Farmers who are interested in yield primarily should pay little attention to the corn shows until they are conducted on a more practical basis.

Shows are in a state of change.—For the past 15 years corn shows have been undergoing a change, and judges pay more attention to the practical points and somewhat less to the merely beautiful. The weak point in the old corn judging was that most of the really important functions of the corn plant, which have to do with yield, express themselves in other ways than through the shape of ear and type of kernel.

Corn shows and corn judges have an important place in drawing men of like tastes together, but they are no longer having much direct influence in improving the yield of our corn. The Iowa Corn Growers' Association has to some extent recognized this by inaugurating a scientific yield contest.

Corn-yield Contests

Practical farmers long ago discovered that the corn which won at the corn shows was not necessarily high-yielding corn. It was therefore suggested that farmers compete to see who could produce, not the best looking corn, but the most corn per acre. Such contests demonstrated that it was possible in the South, by means of extremely heavy fertilizing combined with a favorable season, to produce over 200 bushels per acre. On rich clover sod land in the North it was found that occasionally, when all conditions were favorable, more than 130 bushels per acre could be produced.

Ira Marshall of Dola, Ohio, for instance, on exceedingly rich black muck land recently in alfalfa and heavily manured and fertilized with commercial fertilizer, obtained yields of

157 bushels per acre or better for the years 1925, 1926, and 1927. These yields were on a 10-acre field and were officially verified and corrected to 20 per cent moisture. Mr. Marshall has used the small-eared Clarage variety planted in hills 33 inches apart each way with an average of 3.5 stalks to the hill. This is twice as thick planting as is usual in the Corn Belt and would result in small nubbins if the soil were not very rich, retentive of moisture, and heavily fertilized. It is important also when corn is planted this thickly to have a rather small-eared variety.

Practical farmers in Iowa and Illinois say that they have no time to fool around with a pet acre or a pet 10 acres which will not win a prize unless they get some lucky rains at just the right time in July and August.

As a result, acre yield contests are now used for the most part as a device to interest farm club boys. In this way, these tests have done an immense amount of good, definitely starting many boys on the path of becoming genuinely interested in all that makes for good farming.

Best type of test.—The best type of corn-yield contest involves growing several strains of corn side by side on the same land, to see which sorts will yield the most when all conditions are alike. This type of contest should be conducted for at least three years, and preferably for five. Since practical farmers are not in position to do the careful experimental work involved in this kind of a contest, it has been the custom for the county agent, the experiment station, or the Corn Growers' Association to supervise the planting and weighing. All the farmer who enters this kind of a contest has to do is to furnish a few pounds of seed (in some cases he also pays an entry fee of a few dollars to defray part of the expenses). The farmer has none of the bother of growing or harvesting, but at the finish receives the benefit of knowing how his seed compared in yielding power with other strains of corn grown under exactly the same soil and moisture conditions. If his corn has done well, he may develop quite a seed business. If it has done poorly, he will find it advisable to buy corn from someone whose corn has done well,

growing the two sorts side by side on his own farm at first in order to verify under his own conditions the results of the yield test.

Woodford County test.—The first carefully conducted three-year corn yield contest of this sort was the Woodford County, Illinois, test, which was begun in 1919 and completed in 1921. Seed from 120 Woodford County farmers was entered in this test in each of three years. These 120 sorts were grown side by side in two different places in the county. Every other row across the test field was a check sort not entered in the contest. By correcting the yield by means of the adjoining check, it was possible to take soil variations into account. The Krug strain of Reid Yellow Dent, which stood at the top as an average of the three years, outyielded the average corn in the contest by 6.6 bushels per acre, and the poorest, which was also a strain of Reid, by 17.1 bushels. The ten high yielders were grown again side by side in a number of different places in Woodford County, in 1922, and again the Krug corn outyielded the others.

Iowa yield test.—The Iowa corn-yield contest was begun in 1920 by the Iowa Corn Growers' Association. The Iowa experiment station assists in planting and harvesting the plots of the strains, which are grown side by side under the same conditions. The state is divided into twelve districts with a testing station in each district. Each farmer who enters designates which district his corn is to be grown in. A few farmers enter their corn in several districts, but most of them make only one entry and that in the district in which each lives.

At a testing station, ten replications of three rows each are grown of every sort entered. The plots are all planted by hand so that exactly the same number of kernels will be planted in each one. In the fall, each plot is weighed up separately and samples are taken so that all weights can be reduced to shelled corn of the same moisture content. All of this work is done so carefully that the expense per entry at one testing station is about $4. Each farmer who enters, however, pays only $3, the

other $1 being borne by the Corn Growers' Association and the State of Iowa.

In the early years of the Iowa corn-yield test, most of the highest yields in northern Iowa were Silver King, and in the southern half of the state Reid Yellow Dent. In 1923, however, high-yielding yellow strains were discovered for northern Iowa. For many years these yellow sorts have definitely outyielded Silver King and other white varieties which formerly dominated northern Iowa. McArthur's Golden King has been outstanding as an early yellow sort for northern Iowa. In the southern half of Iowa, crosses of inbreds were entered for the first time in 1924, with the result that they took most of the high prizes. Since 1924 the crosses of inbreds have had a definite advantage over the ordinary open-pollinated varieties. Hybrids and open-pollinated sorts are classed separately because of the superior yielding ability of the hybrids. Outstanding strains of Reid Yellow Dent brought to light by the Iowa corn-yield contest are: Black, Krug, Steen, McCulloch, Kirkpatrick, Clampitt, and Osterland. Ioleaming, which is a cross of Leaming and Reid, has done remarkably well in north-central Iowa.

Significance of yield test.—One year of corn-yield testing does not mean much unless the sorts which win have an unusual lead above the average. Three or even five years of testing are necessary if the different kinds are to be subjected to different climatic conditions. The object of a yield test is to find sorts which will yield the most, not in a cold year, nor in a hot year, but in the average run of years. This means that farmers who enter a corn-yield contest should put their corn in for at least three years before they feel sure that their corn has been definitely proved to be good or bad. If their corn proves to be low in yielding power, the next thing is to buy a bushel or two of seed from men whose corn has proved to be of high yielding power and compare this corn with the home corn under home conditions. After a year or two of this, a farmer may find that

he can make several hundred dollars a year more by using a higher-yielding sort of seed corn.

Most farmers never enter a corn-yield contest. In order for them to get benefit out of such a test, the thing for them to do is to buy a little seed each year of men whose corn has yielded well in the test. This high-yielding seed should be planted in the home field in such a way that a fair comparison can be made of the dry yield of the home corn and the so-called high-yielding corn. A number of Iowa farmers have done this and as a result are now several hundred dollars richer each year.

In the future, it is to be hoped that there will be special corn-yield contests for poor land, for early corn, and for silage corn. The corn-yield contests, if properly conducted, will bring to light splendid corn material which the inbreeders and cross-breeders can use to develop superior combinations.

SELECTED LIST OF REFERENCES

Williams, C. G. Corn Experiments. Ohio Bul. 282. 1915.

Love, H. H., and Wentz, J. B. Correlations Between Ear Characters and Yield in Corn. Jour. Amer. Soc. Agron. Vol. IX. Pp. 315-22. 1917.

Kiesselbach, T. A. Corn Investigations. Nebr. Research Bul. 20. 1922.

Hayes, H. K., and Alexander, L. Methods of Corn Breeding. Minn. Bul. 210. 1924.

Hughes, H. D., and Robinson, J. L. Relation of Certain Ear and Kernel Characters of Reid Yellow Dent Corn to Yield. Iowa Bul. 257. 1929.

CHAPTER XVIII

HISTORY AND IMPORTANCE OF CORN

History

CORN is one of the few standard crops that originated in America. Early writers disagreed as to the place of origin of corn, some maintaining that it came from eastern Asia; others that it came from Africa, while still others said it was of American origin. The last is now generally accepted as the true theory. The main reason for the acceptance of this theory is that no mention is made of corn in the early writings, and, with one possible exception, no mention is made of it until the discovery of America, in 1492. This possible exception is a tradition of the Norsemen that they found the grain being cultivated by the Indians when these explorers landed on the western continent, in 1002. Another reason for the belief that corn originated in America is that it was generally cultivated by the natives when Columbus first discovered the continent. Its antiquity in America is also indicated by the specimens found in the ruins of the Cliff Dwellers and Mound Builders. The highlands of Peru, Bolivia, and Ecuador and southern Mexico are credited with being the original home of corn. Peru has been favored by some because Dr. W. F. Parks found, in 1914, a piece of pottery, thousands of years old, resembling a fossil ear of corn and looking much like some present-day varieties grown in that country. Southern Mexico is favored by others because it is the native home of a wide diversity of corn types and of teosinte, a close relative of corn.

According to Harshberger, the Indians probably first found

the plant in Mexico, in the region above 4500 feet altitude and south of 20° north latitude and north of the river Coatzacoalcos and in the isthmus of Tehuantepec. It probably reached the Rio Grande about 700 A.D., and by the year 1000 had reached the coast of Maine. These dates are more definite than most writers give, but the evidence of wild grasses related to corn growing in southern Mexico suggests Mexico rather than Peru as the place of origin.

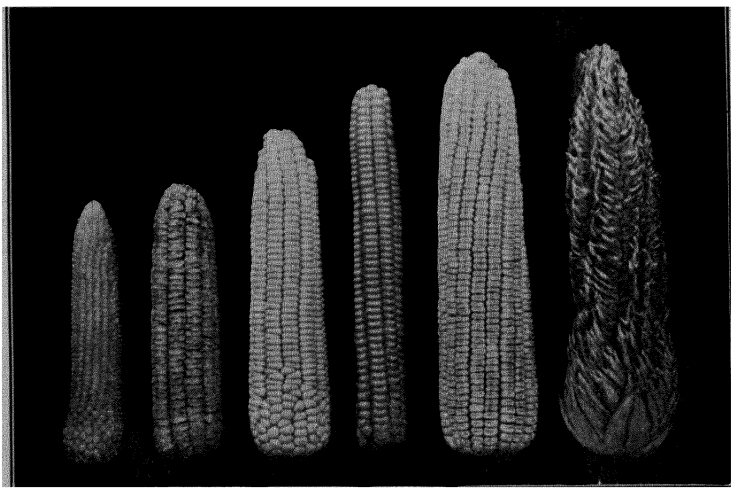


FIG. 83.—Representative ears of pop, sweet, flour, flint, dent and pod corn. (Courtesy U. S. D. A.)

Originated from wild grass.—In southern Mexico there are two native wild grasses, gama grass and teosinte, both of which are closely related to corn. Corn has never been found growing wild, and many are of the opinion that corn has been developed from teosinte, which resembles corn more closely than any other wild grass. Other writers think that both corn and teosinte developed many thousands of years ago from a common ancestor, possibly from such a grass as perennial teosinte, recently

found in southern Mexico. Others think that annual teosinte is a cross of corn and perennial teosinte.

Teosinte has a tassel just like corn, and the seeds are enclosed by husks and borne in the axils of the leaves. The teosinte ear (there is no cob) is about 3 inches long and is composed of five to ten kernels arranged end to end. Teosinte readily crosses with corn, which again suggests that the two plants have a common ancestry or that corn originated from teosinte.

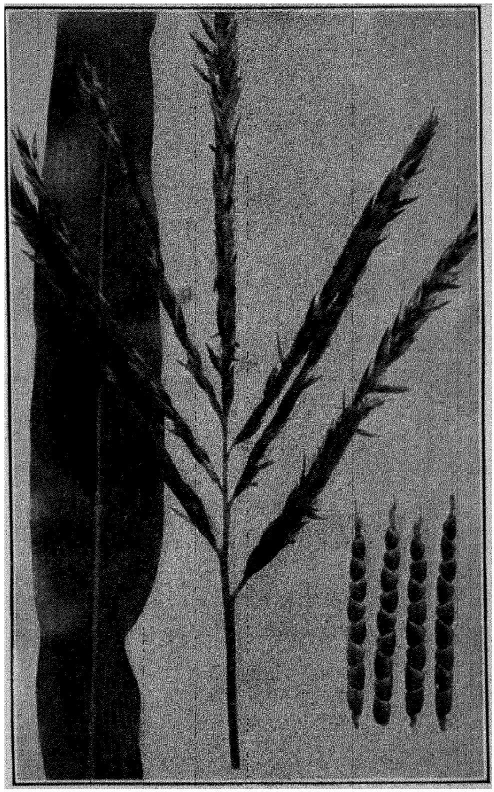


FIG. 84.—Teosinte tassel and ears. Teosinte ears have no cob.

Corn and teosinte both doubtless trace back to a plant resembling gama grass, a plant having a tassel at the top and tassel-like structures on long, lateral branches—all tassels bearing male flowers on the upper part of the tassel and female flowers on the lower part. In the process of evolution and diversification, the tassels at the top came to produce only pollen and the tassels on the lateral branches only seeds, and at the same time the lateral branches were shortened until the tassels were enclosed by husks. It is also probable that in this

evolution the lateral tassel developed into an ear. Nature has been aided by man, of course, in the selection of our present types of corn.

Early types of corn.—Most writers speak of flint, soft, gourd-seed and sweet types of corn as being grown by the Indians and the early settlers. Indications are that the dent varieties of to-day are the result of both accidental and intentional crossing of gourd-seed and flint types. This is discussed fully in Chapter XIV.

The Atlantic Coast farmers, from 1800 to 1840, made a real effort to get high-yielding strains of corn. The farm papers of 1819 to 1822 tell of several instances of getting Maha (undoubtedly Omaha Indian) corn from Council Bluffs—now a part of Iowa. This corn was an eight-row soft corn type, and several of the eastern farmers claimed yields of more than 100 bushels to the acre. The Sioux yellow, ten to twelve-row flint corn, was introduced from the West by several growers, and there were several introductions of a Canadian flint corn. These introductions, together with the local varieties, are probably found to some extent in all of our present-day varieties, and help to explain the heterogeneous nature of our present-day types.

In 1836, Lt. A. M. Lea reported: "The large white corn of the South may be produced as far north as Rock Island, and yields from 50 to 100 bushels per acre, but the yellow flint grows well anywhere and yields from 40 to 75 bushels—the latter is the more certain crop."

J. M. Chambers, of Linn County, Iowa, in 1858 wrote: "The yellow flint and the Virginia gourd-seed are the principal varieties."

Early history in America.—Early explorers in America mention the large fields of corn cultivated by the Indians, and remarked about the slowness of Europe to adopt this new grain, which they considered to be so valuable. Columbus first saw corn on November 5, 1492, on the island of Cuba. In 1498, Columbus reported his brother as having passed through eighteen miles of corn on the Isthmus; in 1605, Champlain saw a

field of corn at the mouth of the Kennebec river; in 1609, Hudson saw many fields along the Hudson river, and in 1620, Captain Miles Standish reported a field of 500 acres in Massachusetts that had been cropped the year previous. Drawings made by Hernandez of corn which he found in Mexico about 1600 show the plant with three or four ears on the stalks, and ears with eight or ten rows.

Thomas Hariot, a member of the ill-fated Virginia colony of 1585, wrote in 1588 what is probably the first extended English description of corn as grown in what now is the United States. He stated: "Pagatour, a kinde of graine so called by the inhabitants; the same in the West Indies is called Mayse. . . . The graine is about the bignesse of our ordinary English peaze, and not much different in forme and shape, but of diuers colors; some white, some red, some yellow, and some blue. All of them yeelde a very white sweete flowre; being used according to his kind it maketh a very goode bread."

On November 16, 1620, a group of Pilgrims landed on the Plymouth coast and spied five Indians whom they followed all that day. The next morning, they "found new stubble where Indian corn had been planted the same year." Near a deserted house "heaps of sand newly paddled with hands which they digged up and found in them divers fair Indian corn in baskets, some whereof was in ears, fair and good, of divers colors, which seemed to them a goodly sight having seen none before."

The most important history of corn in this country, as far as the white man is concerned, began with the settlement of Jamestown in 1607. The colonists had a hard time to keep from starvation; and had it not been for the corn obtained from the Indians, the colony would probably have resulted in failure. The Indians taught the colonists how to prepare the ground and plant the corn. The trees were girdled, the ground stirred and the grain planted in hills three or more feet apart. In places on the New England coast, it was necessary to fertilize the ground before it would produce a crop. The Indians showed the colonists how to fertilize with fish. Herring or shad,

which came up the streams by the thousands in the spring to spawn, were caught; and one fish was placed in each hill of corn. One writer of the time said that it took about a thousand fish to plant an acre of corn, and without fish no corn was planted. He also stated that an acre of corn planted with fish yielded as much as three acres planted without.

Corn formed such an important crop with these colonists that many laws were passed regulating the minimum amount to be grown and the methods of caring for it. It was even enacted that all dogs should be tied by the leg during planting time, to prevent their eating the fish. Other laws were passed providing for the payment of taxes in corn. The price when used for this purpose was fixed by law. One writer of the time says that the reason so much corn was grown rather than wheat was because wheat would not grow and mature. The failure of wheat was, of course, due to the growing of unacclimated English varieties.

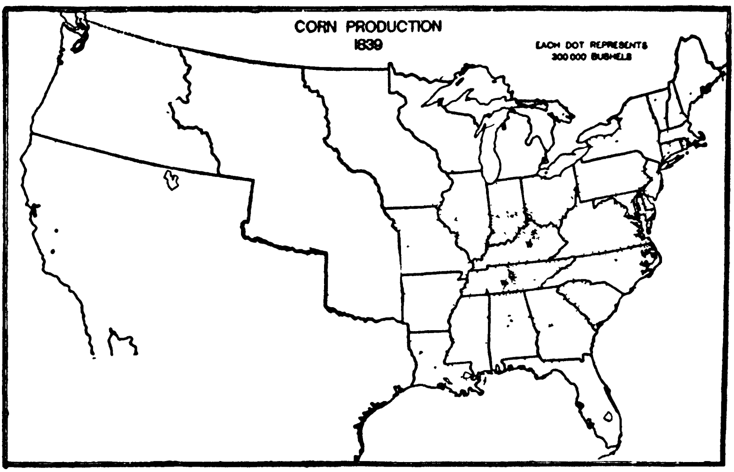
The cultivation of corn in America increased rapidly. In 1609, it is reported that thirty acres were planted. In 1650, there is a record of 600 bushels being exported from Savannah, and from that date on there were exports from the colonists almost annually. In 1770, the total exports were 578,349 bushels, and in 1800 this was increased to 2,032,435 bushels.

Later history in America.—With the opening of the Mississippi valley, the production of corn increased by leaps and bounds. The growers found that corn was peculiarly adapted to this region, and it at once became the principal crop. This section soon became world-famous as the "Corn Belt." About 1870 began the increased use of farm machinery and improved varieties of corn so that a man could tend a much larger area and at the same time obtain larger yields. The 1839, 1859 and 1919 maps of corn production in the United States illustrate very vividly how recently the Corn Belt has come into its own.

Schmidt says that during the fifty-year period from 1849 to 1899 the center of corn production moved north only five miles, whereas at the same time the center of production had moved

westward 480 miles. The center of corn production is now near the Mississippi River, not far from Keokuk, Iowa.

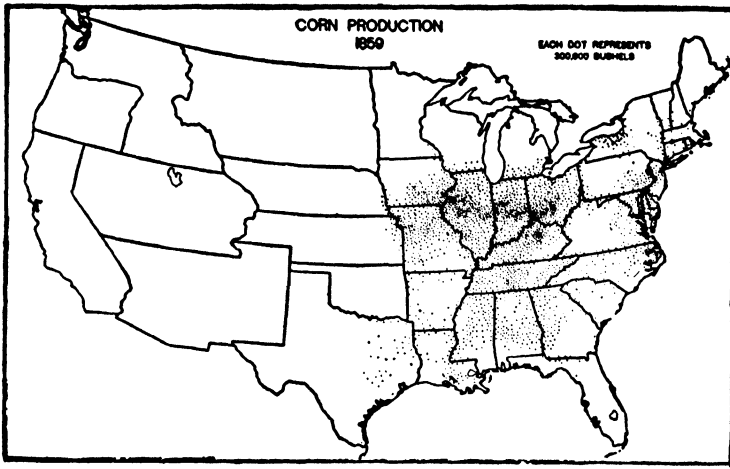
History in the Old World.—Soon after the New World was discovered, corn from the West Indies and Peru was introduced into Spain, Italy, southeastern Europe, India, Africa and China. During the sixteenth century corn growing spread with exceeding rapidity over the temperate and sub-tropical



Courtesy of United States Department of Agriculture.

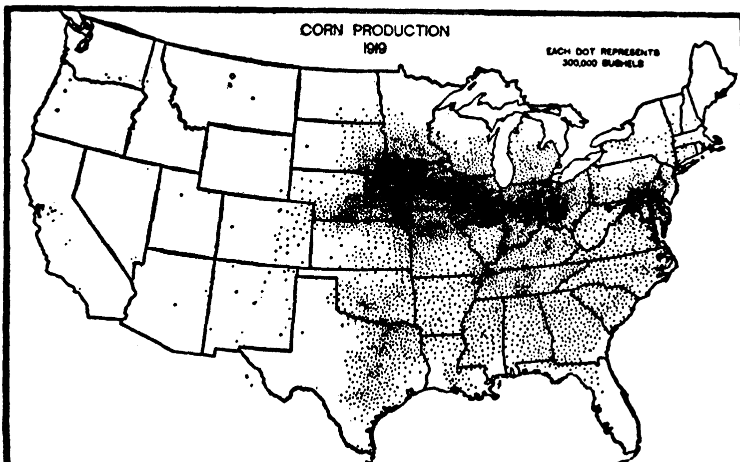
FIG. 85.—In 1839 Tennessee and Kentucky were the leading corn states and the total production of the entire United States was less than the normal crop of Iowa to-day.

regions of the entire world. In no place, however, with the possible exception of a rather limited area in the Balkan states, did corn come to dominate the entire agriculture of a region as it does in the Corn Belt of the United States. Much of the corn grown in Europe has descended from the tropical flints of the West Indies. In the nineteenth century, however, a few Corn Belt varieties were introduced into Europe, but, generally speaking, corn as grown in the Corn Belt has met with very little favor anywhere outside of the Corn Belt, the one outstanding



Courtesy of United States Department of Agriculture.

Fig. 86.—From 1839 to 1859 the center of corn production moved north and west and the Corn Belt as we now know it began to take shape. Illinois and Ohio were the leading corn states in 1859.



Courtesy of United States Department of Agriculture.

Fig. 87.—In 1919 Iowa was the first corn state and the center of corn production was not far from Keokuk, Iowa.

exception being Australia. For further information concerning corn outside of the Corn Belt, see Chapter XIX.

IMPORTANCE OF CORN

Value in the United States.—The value of corn in the agriculture of the United States is well known. In acreage, in multiplicity of uses, in production and in value, it exceeds any other cultivated crop. In recent years the acreage devoted to corn in this country has been slightly greater than the combined acreage of the crops of wheat, oats, barley, rye, rice, buckwheat and flax. The value of the corn crop in the United States exceeds the combined values of these crops by 20 to 30 per cent.

Eventually, the manufacture of corn products in the United States will equal or exceed the meat-packing industry. Even now, more than 60,000,000 bushels of corn every year are used in the manufacture of such products as starch, corn syrup and corn oil. Corn is one of the greatest potential sources of the alcohol which will doubtless be needed to run our automobiles when eventually the crude petroleum supply is exhausted.

Valuable as a sustainer of life among primitive peoples in peace and war, corn, ever since the early days of the Jamestown and Plymouth colonies, has bulked large in the white man's existence on this continent. There is no indication that it will ever be otherwise.

Value in the Corn Belt.—Corn is the basis of wealth in the agricultural region known as the Corn Belt—Iowa, Illinois, Ohio, Indiana, eastern Nebraska, southeastern South Dakota, northern Missouri, southern Minnesota and northeastern Kansas. One hundred and forty million acres of the richest land in the world lie in this Corn Belt of the United States, of which Davenport, Iowa, is not far from the center of production. As may be judged from the map on p. 268, the Corn Belt extends about 100 miles west into Nebraska, 75 miles northwest into South Dakota, 50 miles north into Minnesota and eastward through Iowa, the northern two-thirds of Illinois, Indiana and

the western half of Ohio. This region is the Corn Belt as it exists in the fourth decade of the twentieth century. As time goes on, it may shift a little to the northwest.

Of the 140,000,000 acres in the American Corn Belt about 85,000,000 acres are plow land, and of this plow land about one-half, or 45,000,000 acres, are put into corn. Roughly, 20,000,000 acres are in tame grass meadow and 20,000,000 acres in oats and wheat.

It is corn that enables these middle-western states to produce such a surplus of pork and beef. The good homes, high land values, and prosperity of the Corn Belt are a direct outcome of the wealth that the corn crop brings to this region. The corn crop of the Corn Belt is the world's greatest bulwark against famine. In times of need, a part of the crop may be diverted from its customary use as an animal food to its more economical use as a human food.

During the spring, summer and fall, the Corn Belt farmer spends nearly three-fourths of his man and horse labor on corn. He puts twice as much time on this crop as on all of his other crops together. Corn is at the center of Corn Belt agriculture. Wheat, oats and hay are grown chiefly to rest the land in preparation for more corn and to use farm labor at seasons of the year when it cannot be employed in growing corn.

The Corn Belt farmer feeds nearly half of his corn to hogs. It is only in rather limited areas, as in central Illinois and parts of northwestern Iowa, that it is customary to ship the greater part of the corn to market in the form of grain. In all sections, one-sixth to one-fourth of the crop is kept at home to feed to horses. This part of the crop is, in a sense, just as much fuel as the gasoline used to run a tractor. Roughly, one-fifth of the Corn Belt corn is sold in the form of fat cattle, dairy products, chickens and eggs. For decades to come, the greater part of the corn of the Corn Belt must be sent to market in the form of livestock or livestock products. But after the population of the United States passes 150,000,000, there will be an ever-increasing per-

centage of corn consumed by people and a smaller percentage consumed by fat cattle and fat hogs.

The Corn Belt of the United States is the only place in the world where there is such a large area of fertile land favored by a rainfall of 10 to 18 inches during the four months following corn planting and an average mean temperature during the thirty days centering around tasseling time of 70 to 80°. The only close approach is in north-central Argentina, in the provinces of Buenos Aires, Santa Fe, Entre Rios and Cordoba. And in this possible corn belt of Argentina, winter wheat, alfalfa and flax are so profitable and the chance of devastating summer drouth is so great that there probably never will be more than 60 per cent as much corn grown as in the American Corn Belt.

SELECTED LIST OF REFERENCES

HARSHBERGER, J. W. Maize—A Botanical and Economic Study. Bot. Lab. Univ. Pa. Vol. 1. No. 2. 1893.

WILL, G. F., and HYDE, G. E. Corn Among the Indians of the Upper Missouri. The William Harvey Miner Co. St. Louis, Mo. 1917.

BIGGAR, H. H. The Old and the New in Corn Culture. U. S. D. A. Yearbook. Pp. 123-36. 1918.

KEMPTON, J. H. Maize and Man. Jour. Heredity. Vol. 17. No. 2 Pp. 32-51. 1926.

KULESHOV, N. N. The Geographical Distribution of the Varietal Diversity of Maize in the World. Bul. Apl. Bot. Vol. 20. English Summary. Pp. 506-9. 1929.

CHAPTER XIX

COMPETING CORN-GROWING REGIONS

THE outstanding corn-growing areas of the world are characterized by a mean temperature of 56 to 70° at planting time, a mean temperature of 67 to 81° at tasseling time, a rainfall of at least 5 inches, one year with another, for the fifty-day period centering around tasseling time, and a soil moderately rich and fairly easy to cultivate. In the best corn-producing sections of Iowa and Illinois, the mean temperature at planting time is around 61° and at tasseling time around 75°; the rainfall averages about 8 inches, one year with another, during the fifty days centering around tasseling time, and the soil is unusually rich and easily cultivated. There are very few large bodies of land in the world which possess the same combination of factors so favorable to corn as the Corn Belt. Some of the other corn-growing sections are described in the following.

CORN GROWING IN THE COTTON STATES

Probably more corn is produced in the cotton states than any other one section outside of the Corn Belt. Ordinarily, about 35,000,000 acres are planted in these states, as compared with about 45,000,000 acres in the Corn Belt. Because of poor soil, however, the yield averages less than 20 bushels per acre, and the total output of corn in the cotton South is less than half as much as in the Corn Belt. Nearly all of the corn raised in the cotton South is consumed at home. Practically none of it reaches such primary markets as Kansas City, St. Louis and Chicago.

From one-fourth to one-third of the improved land of the cotton states is put into corn. Cotton has first place in the eyes of the Southern farmers, but corn is a close second.

In such cotton states as South Carolina, Georgia, Mississippi and Louisiana, the corn is generally planted during March or early April, but may be planted as late as June or even July. Plowing is quite generally done with a middle-buster, which is a double mold-board plow substantially the same as a lister, but with no planting attachment. In some sections, especially the western part of the Cotton Belt, the corn is listed in the same way as in Nebraska and Kansas, but in poorly drained districts it is planted on top of the ridges thrown up by the middle-buster. Listing seems to be growing in favor except in sections where the rainfall is heavy and drainage is poor. One-horse planters are quite commonly used in the South. Occasionally in the South they plow and use a two-row planter set to check, but this is the exception rather than the rule.

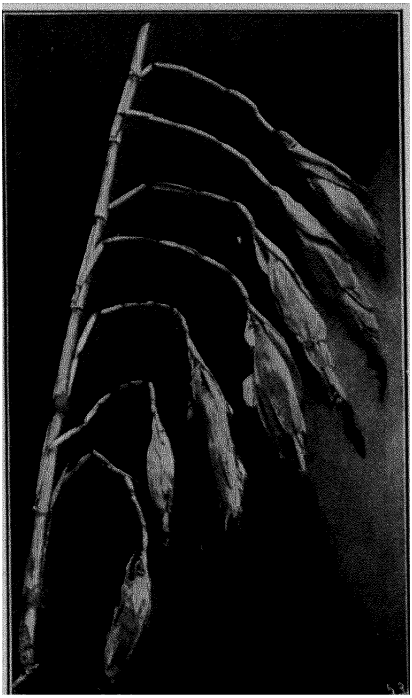


FIG. 88.—An extreme example of southern prolific corn.

The rate of planting in the South is usually only about one-half as thick as in the North, except on rich bottom lands. On exceptionally poor soil, the rows may be spaced 6 feet apart and the kernels 2 feet apart in the row.

Cultivation is much the same as in the North, but much of it is with single-horse cultivators. In parts of the South, considerable hand hoeing is done at the rate of about two acres a day.

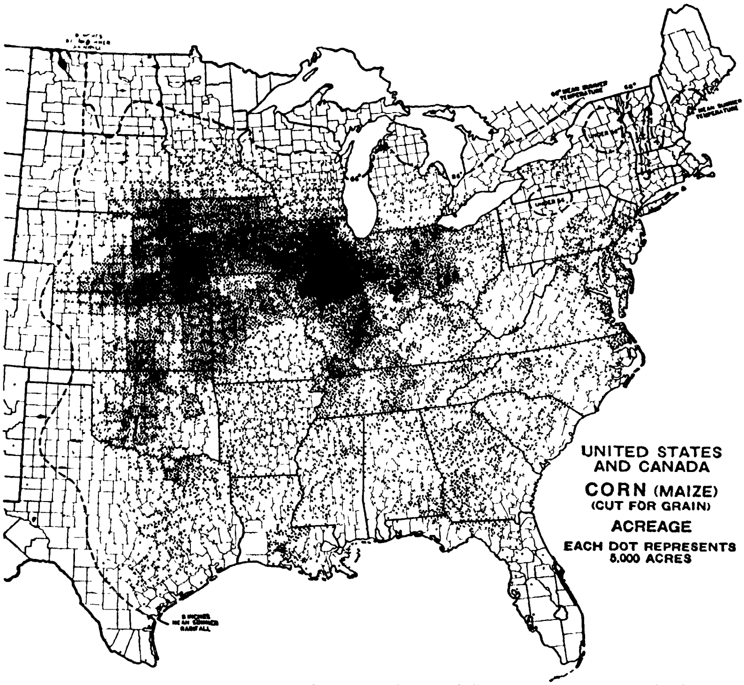
Because many of the soils are poor, corn is more often fertilized in the Cotton Belt than it is in the Corn Belt. A mixture which often gives very good results is 100 pounds of super phosphate and 200 pounds of cottonseed meal, applied either at the time of planting or just before the corn is planted. Sometimes 50 or 100 pounds of muriate of potash are added to this mixture.

The Southern corn root-worm is a very serious pest in the South, and often very severely damages the corn planted in March and early April. Especially is this true in cold, wet seasons. Corn planted in May ordinarily is not bothered. On well-drained land, where this pest usually causes but little trouble, it seems to be the best policy to plant in March or early April.

Throughout the cotton states, the prolific varieties which average nearly two ears to the stalk and oftentimes as many as three, are far more popular than the single-ear varieties which are almost universally grown in the Corn Belt. The ears of these prolific varieties are only about three-fourths as large as the ears of the single-ear sorts, but under Southern conditions, the average prolific plant yields about 15 per cent more than the average plant of the single-ear type. The typical ear of prolific corn carries twelve or fourteen rows and the kernels are rather flinty with a very smooth dent. The husks of well-bred Southern varieties fit tightly to the corn and carry out well past the tip, this husk protection being valued in the South because of the corn ear-worm and weevil, which cause very severe damage to varieties with loose husks.

Climatic conditions in the cotton states are quite favorable to corn, although the weather is frequently too dry at tasseling time for the best results. The rainfall is usually sufficient to produce an abundant crop, and the cotton states would undoubtedly be another Corn Belt if the soil were only richer. As it is, nearly all of the records of corn yielding over 200 bushels per

acre have come from the South, such results being obtained by planting corn thickly on land heavily fertilized. The corn yields of the South will increase in the future as the South grows more soy beans, cowpeas, velvet beans, crimson clover, peanuts



Courtesy of United States Department of Agriculture.

FIG. 89.—Compare this map with the maps of the Argentine Corn Belt and the European Corn Belt. In each case, the dots represent 5000 acres. In the United States, as in Argentina, very little corn is grown where the summer rainfall is less than 8 in. Note that corn is grown uniformly in the cotton states, but that the density of corn planting is not equal to that in the corn belts of Argentina and Europe.

and livestock. As long as the cotton states plant over 33,000,-000 acres of land to cotton every year, it is doubtful if they will ever produce much more than 20 bushels of corn per acre on the average.

Corn Growing in Argentina

The Argentine Corn Belt is located about six hundred miles nearer the equator than the American Corn Belt. At planting time, in November (some corn is planted as early as late September and some as late as December), the temperature is usually about 5° higher than in the Corn Belt during May. At tasseling time, in January, the temperature is about the same as in the Corn Belt of the United States. The rainfall during the fifty days centering around tasseling time averages about the same as in our Corn Belt, but there is a little greater danger of really severe drought. Moreover, there is occasional severe damage caused by the langosta (a grasshopper), which comes in droves from northern Argentina and southern Brazil. The soil is deep and exceptionally rich.

Year by year, since 1927-1928, the acreage, the average acre yield (in bushels), and the exports from Argentina (in bushels), have been as follows:

	Average Acre Yield	(Harvested) Acreage (000 omitted)	Production (000 omitted)	Exports * (000 omitted)
1927–28....	34.6	8,999	311,597	246,240
1928–29...	28.0	9,026	252,408	209,532
1929–30....	26.9	10,428	280,617	206,421
1930–31...	36.2	11,577	419,661	387,365
1931–32....	31.4	9,518	299,329	250,319
1932–33....	28.6	9,373	267,761	209,378
1933–34...	25.3	10,161	256,913	209,478
1934–35....	32.1	14,091	451,943	209,541
1935–36....	30.7	12,367	379,900	311,844

* Exports are for the season following the acreage and production shown. That is, from the production of 311,597,000 bushels (crop planted in 1927 and harvested in the spring of 1928), 246,240,000 bushels were exported between April 1, 1928, and March 31, 1929.

Corn production in Argentina from 1927 to 1935 averaged 325,000,000 bushels, and the exports averaged 250,000,000 bushels. Argentine livestock apparently consumes on the average about 75,000,000 bushels annually, or less than one-fourth the crop, whereas in the United States livestock consumes about 80 per cent of the crop. The great barriers to increased livestock consumption of corn in Argentina are the splendid alfalfa pastures and the fact that occasionally, as in 1911 and 1917 with a yield of only 3.5 and 6.5 bushels per acre, the crop is almost an entire failure. In such years, a livestock industry

FIG. 90.—Corn shelling in Argentina.

built on corn suffers the greatest inconvenience. The possibilities of Argentina as a pork-exporting nation are a little uncertain as long as there is the probability of almost complete crop failure once in every ten years. In this respect, Kansas and Argentina are much alike.

In Argentina the farmers try to plant their corn as early in the season as possible, in order that the corn may be well along by late December and January, which is the dry period of the corn-growing season. In the Corn Belt most of the corn is planted during late September and October but some is planted as early in the season as late August and some as late as December. In some years the corn which is planted during August is injured by frost so the practice of planting it this

early is not widespread. There are some farmers who harvest their wheat in December and then plant the ground to Cuarenton, a quick-growing flint variety of corn.

The corn is planted in rows about 70 centimeters (28 inches) apart and 20 centimeters (8 inches) between plants within the row. At this rate of planting the number of plants per acre is more than 28,000. It appears that the plants might produce larger ears and possibly increase the yield if the planting was made less dense, but the Argentine farmers seem to be satisfied with yield and size of ears obtained from thickly planted fields and do not seem anxious to change.

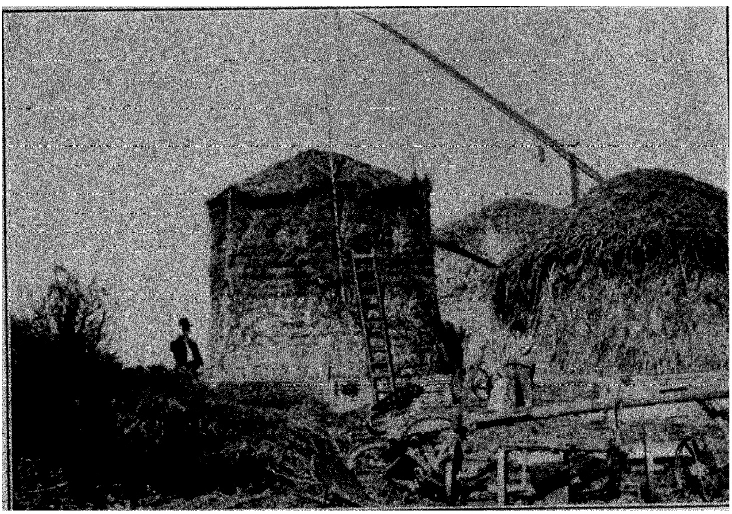
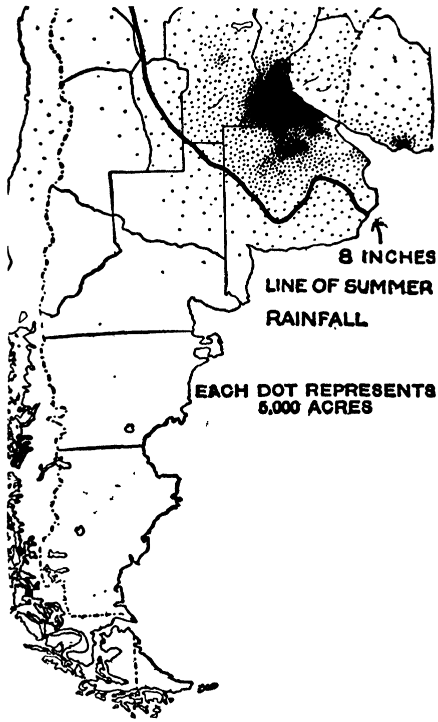


FIG. 91.—The Argentine troje (corn crib) has sides made of cornstalks.

American listers are much in favor in the southwestern part of the Argentine Corn Belt. A three-row corn planter is used in some sections, but it is set to drill rather than check. Corn husking is at its height in April, May, and early June. The corn is husked into baskets about the size of large wastebaskets, and then poured into large sacks; the sacks are dragged

to the edge of the field, where they are picked up with a team and wagon, and the corn is hauled to a crib the sides of which are made of cornstalks. Many of these are round and much like the temporary, uncovered fence cribs seen here and there in the American Corn Belt.



Courtesy United States Department of Agriculture

FIG. 92.—Argentine corn production is centered in northern Buenos Aires, southwestern Entre Rios, southern Santa Fe, and southeastern Cordoba. Very little corn is grown southwest of the 8-in. line of summer rainfall. Rosario, the Chicago of Argentina, on the River Plata, is a port for ocean-going vessels and is located in the center of densest corn production.

Much of the surplus corn is shelled on the farm and shipped by rail to Rosario (the Chicago of Argentina), which is about two hundred miles away from the typical farm. Rosario is an ocean port, and the cost of shipping from Rosario to either New York or Liverpool is usually slightly less than the cost of shipping from Chicago to New York. The Argentine farmer really has lower transportation costs separating him from most of the big markets of the world than the American farmer.

The Canario and Colorado varieties are the most popular in Argentina. Casilda, Piamontese, and Cuarenton are also popu-

lar varieties in the Corn Belt. In the more arid regions (on southern edge of the Corn Belt) Longfellow Flint, Gehu Flint, and Long White Flint are the most important varieties. The grain of the North American varieties does not enter the export channels but is fed to animals on the farms in the region where it is grown.

Although dent varieties of corn yield more than the flint varieties in a good season, nevertheless the Argentine farmers continue to grow the flints because they seem to be more drought resistant and are especially adapted for export use. The kernels of the Argentine flint varieties are small and tend to dry out more rapidly and absorb moisture more slowly than the large soft dent kernels. As it takes several days to ship corn from Argentina across the equator to North America or Europe it is necessary that the corn be rather dry before leaving Argentina and not absorb too much moisture en route. Dent corn absorbs too much moisture in a short time to be shipped across the equator without spoiling. Dent corn will probably not be grown very extensively in Argentina until the country is able to consume more corn within its boundaries rather than exporting the grain.

Another reason why flint corn is grown almost exclusively is the damage done by storage weevil in dent corn. The climate in the Corn Belt is so mild that the weevils are able to survive the winters. It is almost impossible to store even flint corn one year on the farms because of the damage done by the weevils, and the damage seems to be even greater in dent corn.

Most of the corn is shelled on the farm in the fall (May or June) and put in burlap bags which hold 130 to 150 pounds each. The bags are transported to the nearest railroad center on large four-wheeled wagons pulled by several horses, or if the farmer lives near a paved road, trucks and trailers are often used (Fig. 93B). At the railroad center the bags are piled in a large one-story building and stored until the owner wishes to ship the grain to some seaport. To be shipped on the railroad

the bags are put on flat cars and then covered with a canvas tarpaulin to keep them dry.

The farmers in the Argentine Corn Belt are often plagued by invasions of the langosta (Fig. 93C). These grasshoppers over-winter in northern Argentina and in Bolivia. With the advent of warm weather in the spring the old langostas fly southward in swarms—they are often assisted in their flight by the northerly winds. The old langosta lay their eggs usually in

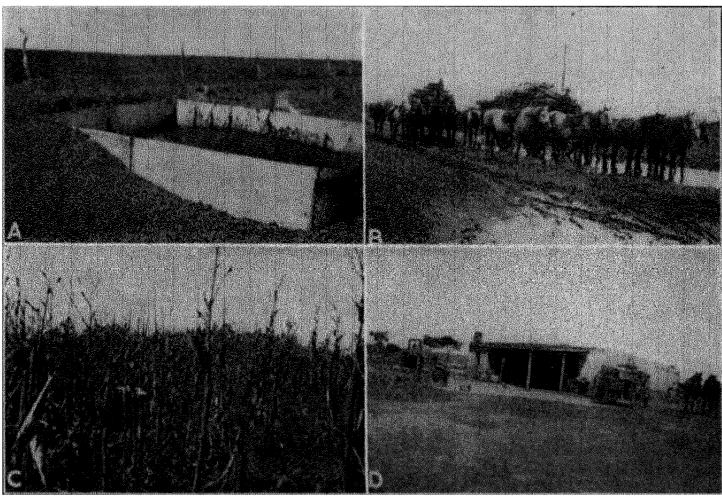
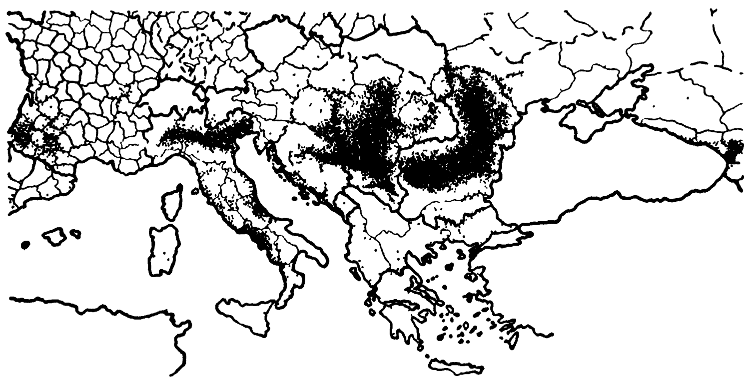


FIG. 93.—With the corn growers in Argentina. A. Fighting grasshoppers—a corral in which the insects are caught. B. Hauling grain to market. C. How grasshoppers devastate the corn. D. A typical farmer's home in the province of Cordoba.

soil which is hard and compacted, i.e., in pastures and roads. As yet no effective method of controlling the old grasshoppers has been found.

Before the eggs hatch the farmers set up metal barriers 20 inches high around the fields which are to be protected from the young grasshoppers. Small corrals are made of the same ma-

terial outside of the field barrier, and a dirt approach is constructed to the corrals so when the grasshoppers start in search of food and come to the barrier they will follow it along to the approach, which they ascend, and then push themselves into the corral, from which they are unable to escape (Fig. 93A). The farmers destroy the grasshoppers by burning them, as often as is necessary. These metal barriers may be rented from the government at a low price and are very simple to assemble.



Courtesy of United States Department of Agriculture

FIG. 94.—In this map, as in the Argentine and United States maps, one dot equals 5000 acres. Most of the European corn is grown in the Danube region and in northern Italy. The European Corn Belt centers around latitude 48, or farther away from the equator than either the United States or the Argentine Corn Belt.

A variety of flint corn called *amargo* (bitter) is grown quite commonly in northern Argentina and southward to the provinces of Santa Fe and Entre Rios. This variety is somewhat but not completely resistant to the langosta attacks. When the supply of food from other varieties of corn gets scarce the grasshoppers turn on the amargo and destroy it.

In Argentina there are about 18,000,000 acres of alfalfa, 14,000,000 acres of wheat, 8,000,000 acres of corn, 4,000,000

acres of flax, and 3,000,000 acres of oats. It is possible for Argentina to put about 25,000,000 acres into corn year after year, but it is not likely that this will be done until they have a different type of corn farmer. The Argentine corn farmer is typically a share renter (chacarero), who lives in a hovel and keeps no livestock (Fig. 93D). He ordinarily handles one hundred acres of corn and nothing else. A man of this sort will not give corn the intensive care that will enable it to compete effectively with wheat and alfalfa for the use of the land.

During the five-year period before the War, Argentina furnished about 50 per cent of the corn which moved across international boundaries. The Danube basin in southeastern Europe furnished about 30 per cent, and the United States about 15 per cent. Because Argentine corn is found to such an extent on the world market, it is worth while studying the Argentine corn situation with some care.

Corn Growing in the Danube Basin

In the Balkan States, Rumania, and Yugoslavia is located the European Corn Belt. The total acreage is about 20,000,000 acres, or about as much land as is put in corn in Iowa and Illinois combined. Since the peace treaty, half of this corn land is in Greater Rumania. The yield is typically around 20 bushels per acre, with occasional years of failure when the yield is only 10 bushels. The summer temperature averages about three degrees less than in central Iowa and Illinois. The annual rainfall is about 20 inches, or about the same as western Nebraska.

Drought, insects, floods, and hail often cause severe damage. Corn is customarily grown in rotation with wheat, moderately early flint varieties being preferred, so that they can be gotten off in time to seed winter wheat. The flints seem to be largely of the twelve-row, small-seeded type, somewhat similar to the Argentine flints. In large sections of the Balkans the farmers

broadcast the corn in April and plow it under, and then when the corn and weeds are about 3 inches high they go through with a large hand hoe and cut out the weeds and surplus corn and hill up the earth around each plant. Very few corn planters are used, even on the larger estates where scientific methods of growing wheat are general. Where the land is plowed before planting, the customary method of planting is to drop by hand into holes made with a pointed stick.

The corn is quite commonly harvested by cutting the stalks off with a hoe and finally husking and storing in a crib made of woven saplings and thatched with straw.

In Hungary, the methods are better than this, but on the whole the Danube corn is produced by peasants who know nothing about modern methods of corn growing. A large part of the Danube corn crop, which is not exported, is consumed by the peasants, the per capita consumption being about 12 bushels, or probably higher than that of any other part of the world. The extent to which the Danube corn is eaten by human beings may explain why the small-seeded flints are so extensively grown.

Before the War, the surplus Danube and Argentine corn quite largely determined corn prices at Liverpool, Amsterdam, and Hamburg. Dent corn from the Corn Belt of the United States occasionally had some influence in years of exceptionally large crops.

Corn Growing in Mexico

Mexico, the original home of corn, grew until 1912 a larger acreage than any other nation aside from the United States. A large percentage of the crop land of southwestern Mexico is put in corn. The yield is low and the crop is consumed entirely at home by people (in the form of tortillas) rather than by animals. They plant about 8,000,000 acres.

Corn in Western Europe

Italy with 4,000,000 acres, Spain with 1,500,000 acres, and southern France with 1,000,000 acres are the chief corn-growing countries of western Europe. The small-seeded flints are in greatest favor. Much of the Italian corn is grown under irrigation. The crop is used chiefly as human food by the peasants. All of western Europe put together produces less than half as much corn as Iowa. Italy, the leading corn country of western Europe, imports several million bushels annually.

Corn Growing in Asia and Africa

Nearly 100,000,000 bushels are grown every year in India, but it is all consumed at home. Considerable corn is also grown in China. Corn in Asia is infected with a serious mildew disease which has not yet reached the United States.

Egypt grows about 60,000,000 bushels annually on her fertile irrigated Nile soil, but none of it leaves the country.

The negro tribes of interior Africa have grown considerable corn for home consumption for several centuries. There is no prospect, however, that any part of Africa, aside from southeastern South Africa, will ever produce much corn for export.

South Africa.—In the southeastern part of South Africa is a large section of land about a mile above sea level where the season is long and the summer rainfall is just right for corn. The temperature is ideal except that during the middle of the summer it averages around 68°, or about 4° too low. The chief drawback is a rather poor soil. Nevertheless, wonderful progress in corn growing has been made since 1900, and there is a possibility that South Africa may rank eventually with Argentina and the Danube basin in providing western Europe with corn. The favorite South African variety is Hickory King, a large-seeded, late-maturing, twelve-row dent, which is also popular on the poorer soils of the northern edge of the

Cotton Belt. Another favorite sort is a variety developed from the Champion White Pearl.

Modern corn-growing methods are employed in South Africa, and some very good English and Boer brains are continually at work on the problem of increasing South African corn production. The South Africans seem to have their eyes fixed quite firmly on the export market. The export trade has been built up on the large, flat white kernels characteristic of Hickory King.

SELECTED LIST OF REFERENCES

STEECE, H. M. Corn Culture Among the Indians of the Southwest. Natural History. Vol. XXI. No. 4. Pp. 414-24. 1921.

LEIGHTY, C. E., WARBURTON, C. W., STINE, O. C., and BAKER, O. E. The Corn Crop. U. S. D. A. Yearbook. Pp. 161-226. 1921.

JONASSON, OLOF. The Agricultural Regions of Europe. Ec. Geog. Vol. 1. No. 3. Pp. 277-314. 1925.

ANONYMOUS. Corn or Maize. Report of the U. S. Tariff Commission to the President of the United States. 1929.

CHAPTER XX

COST OF CORN PRODUCTION

In recent years considerable interest has been shown in production costs of corn. The usual method of figuring the cost of producing a crop of corn, or any other crop for that matter, is to determine the quantities of the physical factors of production, such as hours of labor and power, quantities of seed, fertilizer, and twine, and to convert these physical cost elements to a money equivalent by multiplying the quantities by price or value figures. To these costs are added such items as the cost of using machinery, a charge for the use of land and buildings, and a computed overhead cost for labor, power, and materials used in the general operation and maintenance of the farm.

Calculated in this manner, production costs include charges for the labor of the farmer and members of his family at going wages, and a charge for the use of his land on a cash-rental basis, or in the form of interest on the value of the real estate. If the price received for the product just equals its cost, the product has returned to the farmer enough to cover cash outlay and whatever allowances were included as costs for his labor and use of capital. Consequently, in periods of low farm wages, low land values, and low prices, low production costs are, in general, accompanied by low returns for the farmer's labor and return to capital.[1] It naturally follows that a cost figure of this kind can not be supposed to represent what the farmer should get for his product in order to maintain any specific standard of

[1] *Crops and Markets*, Vol. 13, No. 2, p. 74, February, 1936. (A monthly periodical published by the United States Department of Agriculture.)

living, but more nearly what it would have cost him to hire his work done, and to rent land for farming.

Over a period of years, any real consideration of the cost problem by the farmer involves an attempt to make the best use of his resources. High costs, year after year, mean that his resources as a whole are not being used to best advantage; low costs mean that he is using his factors of production, or his resources, in an efficient and economical manner. It is through such a consideration of costs that the individual farmer may best determine his proper farm organization, and that he may best decide not only what and how much of each product to produce, but also the methods to employ in production. It is through a full consideration by individual producers of all the factors of production that farmers in widely separated regions of the United States are using various proportions of their land and other resources in the production of some of the same crops and classes of livestock.

Considerations involved.—In general, it is not difficult to determine for an individual farm, or an average of a group of farms, the physical quantities of production for a specific crop at a given time. Many considerations are involved, however, in determining valuations to place upon various cost elements. Purchased goods are, of course, charged to the enterprise at actual cost, but it is rather difficult to determine values to place upon such factors of production as the operator's own labor, charges for building and machinery use, barnyard manure, and horse work.

A rough approximation of a reasonable charge for some items is the best that can be done. In some instances the minor importance of the cost item does not warrant any great amount of time and effort in arriving at a cost rate.

Some costs are interdependent in character. For example, the cost of an hour of horse work is dependent, among other things, upon the cost of producing corn, and the cost of producing corn is influenced directly by the cost of horse work.

The cost of keeping horses and the cost of producing the corn fed to the horses might be determined separately by appropriate statistical methods, but this would be so involved that under most conditions such a procedure is impracticable. In lieu of this method rates are usually established on the basis of current market prices and farm values.

Another consideration in figuring production costs has to do with joint costs. The farmer who produces an acre of corn at a given cost obtains from that acre a given quantity of grain and a given quantity of stover or stalk pasture. They are different products having different values. Under such conditions the usual method of procedure is to consider the stover or stalk pasture as a by-product, and to subtract its value from the gross cost per acre in determining the cost of producing the grain. Joint costs involving the production of two important commodities, such as mutton and wool, are generally handled in a different manner. Usually the gross cost is distributed to each product on the basis of the value of each. These are only a few of the problems involved in a consideration of joint costs.

As indicated previously, not all elements of farm costs are cash, or out-of-pocket costs. In calculating the cost of producing corn, the farmer may be allowed for his own labor any wage that seems reasonable; but if the price is not sufficiently high to cover all costs, the farmer has not received the full pay for his work which was allowed in making the cost calculations. It naturally follows that out-of-pocket costs, or current cash costs, are usually considerably less than the total cost arrived at, according to any generally accepted method of calculating costs.[1] A distinction between total costs and out-of-pocket costs is necessary to an intelligent understanding of the reasons why a farmer may continue to produce for many years when total costs, as generally computed, are higher than the price he receives for his product.

[1] *Crops and Markets,* Vol. 13, No. 2, p. 74, February, 1936.

The problem of economically utilizing the farmer's resources, which are his cost elements, involves a consideration of variable and fixed costs. Variable costs are those that are dependent upon volume of production; fixed costs are those that do not change with volume of production. The farmer who hires his corn crop gathered at five cents per bushel pays less for harvesting an acre of corn that produces 40 bushels than one that produces 60 bushels. On the other hand, if he hires a man by the year there is no saving in the harvesting of the smaller crop, unless it would be necessary to hire additional labor in harvesting the larger crop, or unless other farm work was neglected during the harvesting of the extra 20 bushels of corn. Likewise, the cost of depreciation and maintenance of a dairy barn filled with cows is no greater than the depreciation and maintenance cost if only one-half of the capacity is used. On a head basis, however, this cost in the second instance is double that of the cost in the first instance.

Labor and power requirements.—Labor and power requirements for growing and harvesting an acre of corn in the United States vary greatly, depending principally on the utilization of the crop, size of machinery used, size and shape of fields, and the yield of corn as affected by soil and climatic conditions.

In the main producing areas of the Corn Belt when corn is harvested by hand from the standing stalk, labor and power requirements vary somewhat depending on the size of machinery and power units used. On farms operated with 2- and 3-horse teams about 20.4 hours of man labor and 50.0 hours of horse work are required for growing and harvesting an acre of corn; where 3- to 5-horse teams are used about 15.4 hours of man labor and 46.4 hours of horse work are needed; where ordinary tractors are used for such heavy work as plowing and disking, and horses are used for the remaining operations, 13.4 hours of man labor, 25.6 hours of horse work, and 2.3 hours of tractor work will grow and harvest an acre of corn. On farms having general-purpose tractors, and where horses are used

only for light-duty operations, about 12.5 man hours, 15.6 hours of horse work, and 4.7 hours of tractor work will grow and harvest an acre of corn when the crop is husked by hand from the standing stalk.

The amount of labor and power normally required for growing an acre of corn up to harvest on farms in the Corn Belt with different power units is, roughly, as follows:[1]

	Hours of Man Labor	Hours of Horse Work	Hours of Tractor Work
Farms using 2- and 3-horse teams	15 4	40 0	....
Farms using 3- and 5-horse teams.	10.4	36 4	....
Ordinary tractor and horses .	8.4	15 6	2 3
General purpose tractor and horses	7 5	5 6	4.7

The average distribution of the pre-harvest labor and power varies somewhat with size of machines and power units. For ordinary tractor and horse farms, the labor and power units divide roughly as follows: Preparing land, 3.0 man hours, 2.0 horse hours, and 2.3 tractor hours; hauling manure, 2.0 man hours and 4.0 horse hours; planting, 0.8 man hour and 1.6 horse hours; cultivating, 2.6 man hours and 8.0 horse hours; and harvesting, 5.0 man hours and 10.0 horse hours.

On most farms on which horses are relied upon for power, and on many farms with tractors, the crop is husked by hand methods. However, especially on many tractor farms, one-row or two-row corn pickers are often used for harvesting the crop. As compared with the hand method, the use of a one-row picker effects a saving of about 1.7 man hours and 5.8 horse hours per acre, but results in an increase of 1.2 hours of tractor work.

[1] Based upon studies made by the Bureau of Agricultural Economics, United States Department of Agriculture, in co-operation with state agricultural experiment stations.

The use of a two-row picker saves 2.8 man hours and 7.1 horse hours per acre, with an increase of 0.7 hour of tractor use as compared with hand husking.

Thus far, the quantities of labor and power mentioned have their application only when the crop is harvested for grain from the standing stalk. However, in some areas a considerable part of the corn crop is harvested in other ways. Total labor and power required for growing and harvesting an acre of corn by the different methods can be closely approximated by adding the following to the pre-harvest requirements:[1]

Method of Harvesting Corn	Hours per Acre		
	Man	Horse	Tractor
Husked from standing stalk:			
By hand	5.0	10.0	...
With one-row picker	3 3	4.2	1.2
With two-row picker	2.2	2.9	0.7
Cut with binder:			
Fill silo	15 0	15.0	1.2
Shock and shred	16.4	18.2	1.2
Shock, husk by hand, and store grain and stover	25.4	17 7	...
Cut and shock by hand, husk by hand, and store grain and stover	31.0	13.5	...

Other sections.—In the semi-arid sections, such as western Nebraska, where the fields are large and level and preparation for planting largely consists of disking and listing, and where corn yields are much less than in the central Corn Belt, only about 7 hours of man labor, 15 hours of horse work, and 1 hour of tractor work are used for growing and harvesting an acre of corn from the standing stalk. In these areas corn is largely

[1] See footnote on p. 289.

harvested by hand methods. Practically no manure is applied to the corn land.

In the South, where the fields are small and irregular in shape and where small teams and implements are commonly used for producing corn, an average of about 40 hours of man labor and 40 hours of mule work are used in growing and harvesting an acre of corn. Yields in these southern states are very low. However, a considerable part of the corn roughage is saved for feed.

In the northeastern states, fields usually are small and irregular in shape. In these states corn is more heavily manured than in any other part of the country, and yields on an average are somewhat higher than in the Corn Belt. On farms where horses supply the farm power and where the corn is cut, shocked and husked by hand, about 55 hours of man labor and 60 hours of horse work are used for growing and harvesting an acre of corn, including the storing of grain and stover.

On some of the larger farms in both the southern and northeastern states, tractors are used in the production of corn, especially for heavy-duty operations, such as disking and plowing. On these farms, the use of tractors results in some reduction in man labor and a considerable reduction in horse work from the figures indicated for farms operated with horses.

Cost to share tenant.—The cost to the share tenant of producing an acre of corn in the central part of the Corn Belt is the value of the man labor plus the cost of horse and tractor work, seed, manure, machinery other than tractor, and miscellaneous items. With hands receiving $30 per month and board, it may be roughly figured that the cost per hour of man labor is about 20 cents. With corn at 70 cents per bushel, oats at 40 cents, and hay at $12 per ton, the cost per hour of using horses is about 12.5 cents. The cost per hour of tractor work on Corn Belt farms is, roughly, 75 cents.

The share tenant who operates his farm with an ordinary tractor and horses would use about 13.4 hours of man labor,

25.6 hours of horse work, and 2.3 hours of tractor work. With the requirements and the values stated, the cost for man labor would be \$2.68; for horse work, \$3.20; and for tractor use, \$1.73, or a total cost of labor and power of \$7.61 per acre. An additional cost of about \$3.25 per acre would be required to pay other expenses, including seed, machinery other than tractor, manure, and miscellaneous, making a total cost of \$10.86 per acre. Deducting \$1.00 per acre as a credit for the pasture value of the stalks, the net cost per acre to the tenant would be \$9.86. In return for this expense the share tenant gets one-half of the corn-crop.

If the yield is 40 bushels per acre, which is about average for the best sections of the Corn Belt and where this method of renting is followed, the share tenant's cost of producing a bushel of corn is \$9.86 divided by 20, or 49.3 cents. With a 30-bushel crop the cost to the share tenant would be 62 cents, and with a 60-bushel crop, 36.6 cents, after making allowance for the cost of harvesting the smaller and larger yields.

Cost to owner-operator.—The operator who owns his land has all the costs of the share tenant plus taxes, interest on investment in real estate, and miscellaneous farm maintenance costs. If his land is valued at \$100 per acre, he has, at 5 per cent, an interest charge of \$5.00 per acre. To this should be added approximately \$2.50 per acre to cover taxes and general overhead expense, making a total of \$7.50 per acre. Adding the \$7.50 and the \$9.86, which is the share tenant's net cost, gives \$17.36 per acre, which represents the cost to the operator who owns his farm. With a 40-bushel yield, the total cost per bushel would be 43.4 cents for corn in the crib in December. If the corn is held until the following summer the shrinkage amounts to about 16 per cent. The shrinkage plus interest on the value of the corn will increase the cost by about 10 cents per bushel, making a total cost of about 53 cents. If the corn is to be shelled and hauled to market there will be an additional cost of around 4 cents per bushel.

Regional differences.—Regional variations in production costs of corn harvested for grain and corn prices may be illustrated by the following average figures for each of three states for the twelve-year period, 1923-1934:[1]

	Iowa	Pennsylvania	Georgia
Cost per acre:			
Labor and power	$10.38	$19.46	$8 51
Manure and fertilizer	1.92	8 26	2.65
Land rent	8.04	5 65	3.66
Other costs	2 95	3.88	2.44
Total	23 29	37 25	17.26
Value of stalks and stover	0.85	4 89	1.22
Net cost per acre	22.44	32 36	16.04
Net cost per bushel	0.55	0.77	1.04
Value per bushel	0.59	0.80	0.88
Yield per acre (bushels)	41 7	43.2	15 7

During this twelve-year period it cost Pennsylvania farmers 22 cents more to produce a bushel of corn than it cost the farmers of Iowa. However, the state of Pennsylvania as a whole is a deficit corn-producing state, and, largely because of transportation costs from the central Corn Belt, corn prices are considerably higher in Pennsylvania than in Iowa. Thus, the average farm price of corn in Pennsylvania during November, December, and January for the twelve-year period was 21 cents per bushel higher than the price in Iowa, the difference being within one cent of the difference in cost of production in the two states. In Pennsylvania, fields are relatively small and only moderate-sized equipment is used. Corn harvested for grain usually is cut, shocked, and husked, and the stover used for feeding livestock. The cost of labor, power, barnyard manure, and commercial fertilizer for producing an acre of corn

[1] Unpublished data in the Bureau of Agricultural Economics, United States Department of Agriculture.

is more than double the cost of these items in Iowa. Partially offsetting the higher acre costs in Pennsylvania is the value of the stover, which, during the twelve-year period, amounted to $4.89 per acre, compared with a value of 85 cents per acre for cornstalk pasture in Iowa. Also, corn yields in Pennsylvania average somewhat higher than yields in Iowa.

During the same period the cost of producing a bushel of corn in Georgia amounted to 49 cents per bushel more than in Iowa. The average farm value of a bushel of corn in Georgia around harvest time was only 29 cents more than the average farm price in Iowa. Georgia farmers in general grow corn more or less incidentally as a means of furnishing at least a part of the farm needs for grain, and as a means of utilizing available land and labor not devoted to the production of cotton and other cash crops. However, since Georgia farmers have plenty of land and labor, and since the actual out-of-pocket costs in the production of corn are relatively low, it is to their advantage to use a part of these resources in the production of corn. This is true even though returns for their work on corn are considerably less than going wages, which, after all, are governed very largely by wages paid for labor used in the production of cash crops of high value, such as cotton, tobacco, and vegetables.

It is generally believed that over a period of years production costs tend to equal prices, particularly in the better producing sections. This is borne out by the cost and price figures for Iowa and Pennsylvania. Corn for the commercial production of livestock and livestock products is very important in the farm economy in both these states. In the long run, farm wages and the cost of horse work tend to fluctuate with prices received for the products produced. Land values increase or decrease as prices of farm products go up or down. Over a long period of time, these cost elements in particular definitely cause production costs to approach the prices received for the products.

Indices of production costs.—Most cost of production studies are local in nature and are not repeated for successive years over a long period of time. Such studies usually are of limited use in making cost comparisons by areas, or for the United States as a whole. Average cost figures for a state, a region, or the United States, for successive years, are composite measures in terms of money, of changes in the use and value of fertilizer, seed, machinery, labor, and other cost goods, weighted according to the quantities used in the production of an acre of the product.[1] Expressed in terms of cost per bushel or per pound, the figures embody all these things as well as the influence of the yield per acre of the product. Such a series indicating changes in the cost of producing a bushel of corn, and changes in some of the important cost elements, is given below. The series is based upon averages for the group of states composed of Indiana, Illinois, Iowa, Missouri, and Nebraska.[2]

Wages paid hired labor, and the cost of using horses and tractors, remained about the same from 1924 to 1929, inclusive. At the same time land values decreased about 18 per cent. Beginning with 1930, farm wages, land values, and the cost of using horses declined tremendously until in 1933 the cost of these items of production was only about one-half of the average for 1923 and 1924. Tractor use costs declined also, but to a much less degree. Since 1933, the trend in the cost of these elements of production has been upward. Especially is this true of the cost of horse work, which in 1935 stood at 93 per cent of the cost in 1923 and 1924. The large increase in the cost of horse work has been largely due to substantial increases in feed prices.

The trend in the cost of producing a bushel of corn in these states followed closely the trend in the major elements of production, except in years when corn yields were relatively

[1] *Crops and Markets,* Vol. 13, No. 2, p. 74, February, 1936.

[2] Figures adapted from published and unpublished data in the Bureau of Agricultural Economics.

high or low. In 1933 the cost of producing a bushel of corn was only 55 per cent of the average cost in 1923 and 1924. Largely because of low corn yields and abnormal charges for corn acreage abandonment, the average cost of producing a bushel of corn in 1934 was 132 per cent of the average cost in 1923 and 1924.

Year	Trend in Production Costs (1923–1924 = 100)					
	Cost per Hour of Hired Labor	Cost per Hour of Horse Work	Cost per Hour of Tractor Work	Value per Acre of Farm Real Estate	Cost per Bushel of Producing Corn	Yield per Acre of Corn
1923	97	96	100	104	87	113
1924	104	104	101	96	113	87
1925	103	106	101	92	87	116
1926	102	101	106	88	99	98
1927	104	103	102	83	96	102
1928	102	103	101	80	90	107
1929	104	103	104	79	96	102
1930	96	94	101	77	106	83
1931	76	73	93	68	75	95
1932	53	53	88	57	55	114
1933	43	54	83	45	68	92
1934	49	83	86	48	132	69
1935	54	93	88	50	83	95

The general trend in production costs for individual states or for other groups of states probably would follow rather closely the trend for these five states.

Reducing costs.—On farms on which good practices for growing corn and a well-balanced rotation for maintaining the productivity of the soil have been adopted there is no easy way of materially reducing the cost of producing a bushel of

corn. Cost studies invariably show that the farms with the high yields per acre produce corn at a lower cost per bushel than do the farms with low yields. The principal methods for increasing yields and thereby reducing the cost of producing a bushel of corn are: (1) The use of better planting seed, (2) the adoption of a cropping system which will maintain or increase the productivity of the land, and (3) the effective use of farm manure and commercial fertilizer.

SELECTED LIST OF REFERENCES

MOORHOUSE, L. A., and JUVE, O. A. Labor and Material Requirements of Field Crops. U. S. D. A. Dept. Bul. 1000. 1921.

COOPER, M. R., and HAWLEY, C. R. Cost of Producing Field Crops, 1923. U. S. D. A. Circ. 340. 1925.

SELBY, H. E. Big Scale Corn Raising in Montana. Mont. Bul. 171. 1925.

FALCONER, J. I., and DOWLER, J. F. Variations in Costs of Producing Corn, Wheat, and Other Crops in Greene County, Ohio. Ohio Bul. 396. 1926.

MCNALL, P. E., and ELLIS, L. S. Farm Costs and Practices. Wisconsin Research Bul. 83. 1928.

JOHNSTON, P. E., and MYERS, K. H. Harvesting the Corn Crop in Illinois. Illinois Bul. 373. 1931.

THOMAS, H. L., and HOPKINS, J. A. Costs and Utilization of Corn in Seven Iowa Counties. Iowa Bul. 289. 1932.

GARMAN, C. G. Factors Related to Income and Costs of Production on Farms in Marshall and DeKalb Counties, Alabama, 1927-1929. Alabama Bul. 236. 1932.

YOUNG, E. C. Labor and Power Used in Crop Production in Central Indiana. Indiana Bul. 378. 1933.

HARRIOTT, J. F., and VAUGHAN, L. M. Cost Accounts on New York Farms. New York Bul. 554. 1933.

CHAPTER XXI

ECONOMIC FACTORS AFFECTING CORN PRODUCTION

MORE than half of the corn crop of the world is produced in the United States. There is no area in any other country where weather and soil conditions are comparable with those of the Corn Belt. The United States produces such a large proportion of the world crop that the fluctuations in world production are caused very largely by changes in production in the United States. Thus, when the United States harvests a short corn crop, the world crop is short, since it is not possible for high yields in other countries to offset the low yields obtained in the United States.

Corn is also an important crop in Argentina, Brazil, Mexico, Italy, the Danubian countries, and the Union of South Africa (Fig. 95). Argentina is the most important of the competing countries because a large percentage of the crop is exported. Generally speaking, corn is used as a feed crop, but in many countries a large proportion of the crop is consumed directly as human food.

The world corn crop has been between 4,000,000,000 and 5,000,000,000 bushels in recent years. The ten-year (1925-1934) average of world production is 4,403,000,000 bushels. During these years the United States crop, averaging 2,464,-478,000 bushels, was 56 per cent of the world crop. While production in the United States has been on a slight downward trend since the World War, production in most of the other countries has increased. The upward trend of production in countries other than the United States has been sufficient to bring the average of recent years above the output in the years immediately preceding the War. Argentina, the princi-

pal exporting country, harvested an average crop in this period of 318,271,000 bushels, or more than 7 per cent of the ten-year average world crop. The total production of corn in Europe amounted to about 14 per cent of the average world crop and about 25 per cent of the average United States harvest. Italy, Spain, and Portugal have important corn-producing regions. In the region westward from the Black Sea, including the four Danubian countries—Hungary, Rumania, Yugoslavia, and

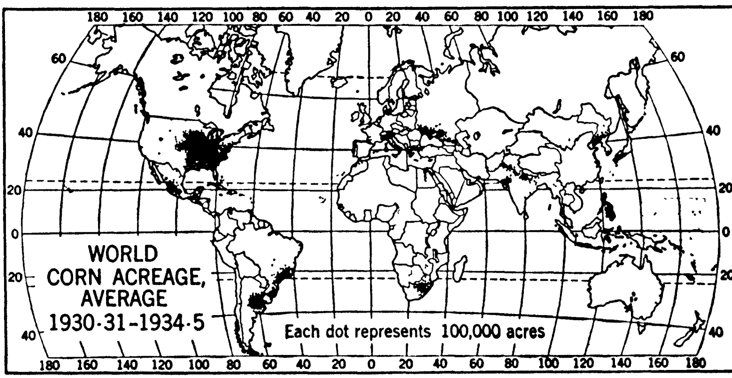


FIG. 95.—More than half of the world corn crop is produced in the United States.

Bulgaria—corn is one of the chief crops and is an important export commodity. In recent years, the Union of South Africa has become an important producer and exporter of corn. The crop in that country averaged 62,661,000 bushels in the ten-year period, or nearly 1.5 per cent of the total world crop.

The area of corn production is restricted by temperature, rainfall, and the length of the growing season. Corn breeding and selection have extended the area somewhat beyond what it might otherwise have been. While the northern and southern limits of corn production appear to have been reached, they may be extended further by the development of earlier-maturing varieties and of improved varieties for silage and fodder.

The extension of corn acreage into areas of low summer rainfall or into areas of low temperatures during the growing period is apparently limited. There remains, however, a large area in which corn growing may be further developed, including land which at present is in other crops, or in pasture, meadow, and hay.

Production in the United States

Corn is the most important crop in the United States. More farmers raise corn than any other single crop, and more land is devoted to it. It is raised in every state, but it is produced intensively in the Corn Belt—a strip of fertile and productive land stretching from western Ohio to eastern Nebraska, and from southern Minnesota and southeastern South Dakota to the northern counties of Missouri. The boundaries of the Corn Belt have moved westward and northward. Although a large proportion of the corn crop raised is kept for livestock feed on farms where grown, the value of corn entering commercial channels is greater than the value of many crops. Whatever influences the corn crop—whether it is rainfall, temperature, frost, change in the cost of production, change in demand, price, or income—concerns many Americans.

Corn, the leading grain from the standpoint of productivity, was raised in 1934 on 71 per cent of the total number of farms in the United States in that year. With a corn area of nearly 98,000,000 acres in 1929, there was an average of 15.6 acres of corn on each farm producing it. This was about equal to the average corn acreage per farm for the census years back to 1880 (Table XVI). The 1935 census data applying to the 1934 crop, which was influenced by the drought, do not represent average conditions. The number of farms growing grain as a percentage of all farms in various states is highest in the Corn Belt and in the southeastern states and is small in New England and the western states. In the Rocky Mountains area of the far west, corn is practically unknown as a crop.

TABLE XVI

NUMBER OF FARMS, LAND IN FARMS, CORN ACREAGE, AND RATIO OF CORN ACREAGE TO LAND IN FARMS, UNITED STATES, 1880–1935

Year	Number of Farms	Land in Farms	Corn Acreage (All Purposes) *		Percentage of Corn Acreage to Land in Farms
			Total	Per Farm	
	Thousands	*1000 acres*	*1000 acres*	*Acres*	*Per cent*
1880	4,009	536,082	62,229	15.5	11 6
1890	4,565	623,219	77,656	17 0	12.5
1900	5,737	838,592	94,591	16.5	11.3
1910	6,362	878,798	100,200	15 7	11 4
1920	6,448	955,884	98,145	15 2	10.3
1925	6,372	924,319	100,420	15 8	10 9
1930	6,289	986,771	97,806	15 6	9.9
1935	6,812	1,054,515	92,727	13 6	8 8

Bureau of Agricultural Economics; compiled from official sources.
* Acreage of the preceding fall, as reported by the Bureau of Agricultural Economics.

The value of the United States corn crop is greater than the value of any other crop grown in this country. Based on an average of fifteen years, the value of the corn crop is about two and one-third times larger than that of wheat, one and three-quarters times that of cotton, and nearly twice the value of the combined tame and wild hay harvest. In eight years out of the fifteen (1921-1935) the value of the corn crop exceeded the combined values of wheat and cotton. The farm value of the corn crop has been greater than the farm value of either swine or cattle produced for slaughter. In thirteen of these fifteen years, the value of corn was greater than the combined values of all cattle and swine produced for slaughter.

The long-time trend of corn acreage in the United States was upward until about 1910. The area planted to corn in-

creased steadily from 1866 to 1910, being about three times as large at the end of that period as at the beginning. However, since 1910 the corn acreage has remained about level or unchanged, owing to such factors as smaller export markets for hogs and hog products, the increased production of corn in many foreign countries during the post-war period, the reduced requirements in the United States because of the smaller number of horses, the decreased human use of corn meal, the increased production of barley, and the more extensive use of by-product and mixed feeds.

During the World War, the demand for and the guaranteed price of wheat, together with the scarcity of labor, resulted in a marked increase in the wheat acreage and a decrease in the corn acreage in many states. An unusually large acreage of corn was planted in 1917, however, owing in large part to the reduction in the wheat acreage by winter killing. In 1918 the corn acreage receded to about normal and remained at that level during the post-war years until 1929, when it increased again sharply. A shift from cash crops to feed crops during the early part of the depression occurred, being brought about largely by the decline in monetary returns from the cash crops. The increase in feed-grain production was accompanied by unusually low feed-grain prices, which in turn tended to encourage an expansion in livestock production. The unfavorable corn prices resulting from the increased acreage and production, together with the influence of the drought in various areas, again reduced the corn acreage in 1933 and 1934. The efforts of the Agricultural Adjustment Administration were also a factor. Some recovery in the corn acreage took place in 1935 and 1936.

The most pronounced geographical change or shift in the acreage of corn during recent years has occurred in the north central states. The twelve states in this group include the area commonly known as the Corn Belt states. The north central states had 60.1 per cent of the total United States corn acreage

during the five years 1900-1904, and 63.4 per cent in the period 1929-1933. In the former period these states produced 71.1 per cent of the total United States crop, and in the latter period 73.7 per cent. Breaking down the north central states into several groups, it may be observed that the acreage in the five northwestern Corn Belt states increased sharply, whereas decreases took place in the important corn-producing states Illinois, Missouri, and Kansas, with smaller decreases in Indiana and Ohio. The 1934 drought reduced the proportion of the total United States acreage harvested in the Corn Belt to 57.8 per cent, and in 1935 it was 58.1 per cent. The 1934 drought also reduced the proportion of the crop harvested in the Corn Belt. The trend of acreage in the states outside of the Corn Belt was slightly upward from 1900 until the close of the World War, when it declined sharply to a lower level. Some increase occurred in the early depression years.

In the southern states there were several changes in the trend of corn acreage. Immediately after the World War the acreage of feed grains in the southern states declined sharply, being maintained at a lower level from 1924 to 1930, and then increased somewhat during the depression years. Since corn and cotton are the principal crops of the South, acreage changes in one are generally at the expense of the other, particularly if the total land under cultivation remains about unchanged. When the income from cotton and cottonseed in a given season is high in relation to the value of the corn crop, the corn acreage and the hog production in the south decrease in the following season. Apparently the greater prospective income from cotton production is expected to provide sufficient additional funds with which to purchase corn meal and pork. When the income from cotton and cottonseed is low in a given season in relation to corn, corn acreage and hog production tend to increase in the following season.

In 1920 the farm value of the corn crop in eleven cotton-growing states was unusually large, 52.5 per cent as great as

the value of the cotton crop. Corn acreage in the following season in these eleven southern states was 34,400,000 in 1925; the ratio of the value of the corn crop to that of the cotton crop was unusually low—only 22.4 per cent, and the southern corn acreage the following season was down to 26,000,000.

From the experience of the years 1920-1935, we obtain the following generalization, in which every increase of 5 per cent in the ratio of the southern corn crop to the cotton crop is followed in the next season by an increase of 1,600,000 in corn acreage.

Ratio of Farm Value Corn Crop to Cotton Crop in 11 Southern States	Corn Acreage 11 Southern States, following Season
Per cent	*Million Acres*
25	25.70
30	27.3
35	28.8
40	30.4
45	32.0
50	33.6

Though corn acreage in the Corn Belt has been relatively stable, it has responded in some degree to the price of corn. During the period 1921 to 1929 a price of 50 cents per bushel tended to maintain a total acreage in the east and west north central states of around 58,000,000 acres in the following year, and a price of around a dollar per bushel tended to expand corn acreage in this area to nearly 66,000,000 acres. The small corn crop of 1924 sold for about $1.05 per bushel, and this was followed in 1925 with 65,600,000 acres in corn in the east and west north central states. The larger crop of 1925 lowered prices to 70 cents, but acreage declined only to 64,000,000 in

1926, and then to 62,000,000 in 1927. As with many farm products, it takes about two years for producers to complete an adjustment to a given price situation. Most of these acreage changes took place in the west north central states; the acreage in the east north central states remained practically unchanged at about 21,000,000 acres throughout the post-war period, while that in the west north central states expanded from 37,200,000 in 1921 to 43,900,000 in 1925, and then to 47,700,000 in 1932.

The response of corn acreage to price in the Corn Belt is of an entirely different character during a major price depression, such as that which developed after 1929. The necessity for maintaining a cash income and the effort to derive a larger proportion of income from livestock products sold in the domestic markets instead of from crops usually sold abroad brought about an expanding corn acreage in the face of declining prices. As the price of corn fell from 84 cents for the 1929 crop to 59 cents for the 1931 crop, corn acreage in the east and north central states increased from 64,900,000 acres in 1930 to 68,700,000 acres in 1932.

In both normal and depression periods the shifts in acreage are relatively small compared with the changes in price.

The yield of corn per harvested acre for the United States since the Civil War has been as high as the 31.7 bushels obtained in 1906, and as low as 15.7 bushels produced in 1934, and has averaged slightly over 25 bushels. From about 1890 to 1905 the trend of yields was slightly upward, but from 1905 to 1915 the trend was downward. Some increase in yields took place during the next ten years, but this has been more than offset by the downward trend since 1925, which was due primarily to the droughts in various parts of the country in the early 1930's. The decline in production of corn since about 1920 was due principally to the smaller yields per harvested acre, since there has been very little change in acreage except during the period 1930-1934, when drought was an important

factor in reducing the acreage harvested as compared with the acreage seeded.

Corn is produced for several purposes (Figs. 96, 97, and 98). First, there is production of corn for grain, which makes up about 85 per cent of the production for all purposes. The proportion of white and of yellow corn produced is not known. When the federal corn standards became effective in 1916,

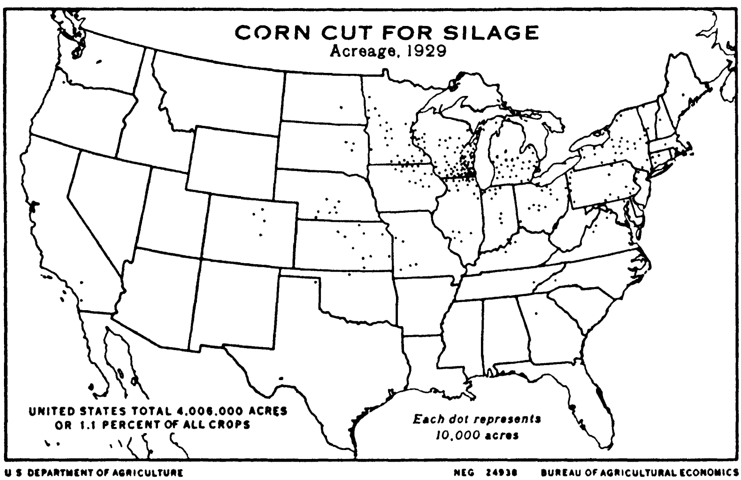


FIG. 96.—Corn is cut for silage chiefly in the Northeast.

approximately 50 per cent of the commercial corn crop was of the yellow class, about 20 per cent in the white class, and 30 per cent mixed corn. Recently, around 80 per cent of the corn receipts at the important markets was yellow corn. The mixed class was reduced to about 6 per cent, and the white class declined steadily to a level of 14 per cent. The reduction in the proportion of mixed corn resulted from the combined efforts of grain dealers, plant breeders, crop improvement workers, and those engaged in grain standardization. Following the World War, yellow corn gained preference, in part because of the

interest in the vitamin content of yellow corn. Corn used for human food is largely of the white class, and the decline in the consumption of corn meal, hominy, grits, and other products of the dry-milling process resulted in a lower level of demand for white corn compared with yellow corn. However, with relegalization of the production of alcoholic beverages, the demand for white corn has increased.

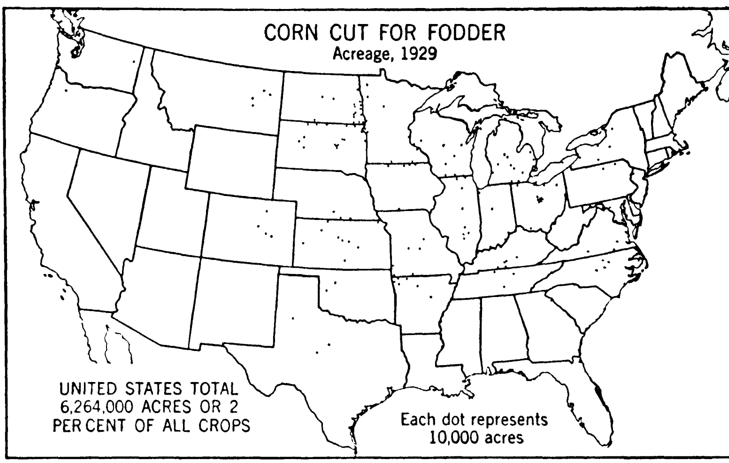


FIG. 97.—Corn is cut for fodder in the outer edges of the corn belt.

In many areas corn is grown primarily for silage, since silage made from corn is palatable and keeps in good condition. Corn silage is used as a substitute for succulent pasture grasses, as a feed for cattle in the winter or when pasture is not available. It has been found to be particularly adaptable as a feed for dairy cows, and consequently silos are more numerous on farms devoted to dairying than on other kinds of farms. In recent years, the average acreage of corn cut for silage is between 4,000,000 and 5,000,000 acres. For many years, the area of corn cut for silage in the important dairy states, Wis-

consin and New York, has been greater than the area of corn cut for grain (Fig. 96). The average yield of silage per acre is about 7 tons.

Corn is cut for fodder in these states and also in the states farther south (Fig. 97). In 1929, a little more than 6,000,000 acres of corn were cut for fodder. The hogging-down of corn is a very common practice in the Corn Belt. It is an effective way of gathering the crop, and also an economical way of fat-

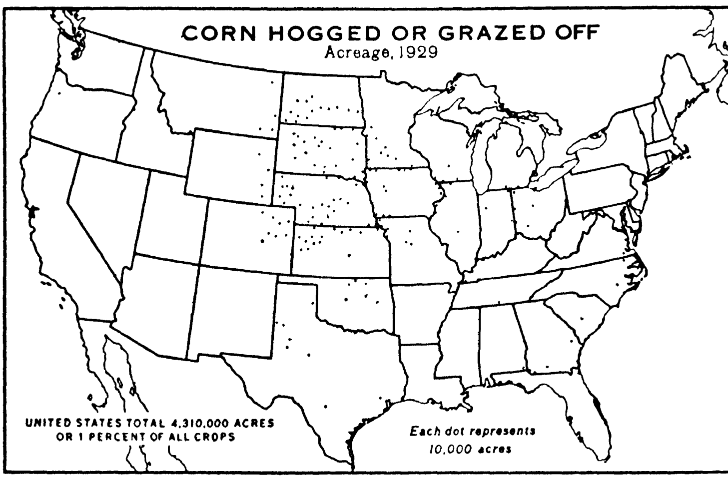


FIG. 98.—Corn is hogged off in Iowa and Northwest corn belt.

tening pigs. Where corn is hogged-down, usually some supplement crop is also grown. Slightly more than 4,300,000 acres of corn were hogged or grazed off in 1929 (Fig. 98). Estimates of these two uses of corn run between 10,000,000 and 11,000,000 acres each year. In 1934, however, the area hogged off, grazed, and used for forage was sharply increased because of the drought, and totaled 22,685,000 acres.

USES OF CORN

Corn is the principal grain for livestock feeding, but it is also used for several commercial purposes. Below are estimates of corn utilization, including the grain equivalent of corn hogged off or fed as silage, for the mentioned uses in two selected periods, 1910-1914 and 1924-1929 (Fig. 99). Data in each case apply only to the first use made of the corn. The consumption figures for the various species of livestock on farms include the whole corn grain, the cracked or ground corn, if processed and fed on the farm, the corn silage, and the corn hogged off, all in the equivalent of bushels of corn grain. The figures do not, however, include the by-products resulting from the milling, or the corn mixed with other ingredients in making commercial or mixed feeds. The "industrial and commercial utilization" figures are made up of corn used in the production of alcohol, spirits, and breakfast foods, and that utilized by the wet- and dry-process millers. The exports consist of corn grain and corn meal, the corn meal being converted into the equivalent of corn grain. Exports of corn meal are deducted from the "industrial and commercial" utilization in order to avoid duplication.

A number of changes have taken place in animal numbers on farms since the period 1924-1929. The greatest changes were in the hog and the horse and mule numbers. During the period 1924-1929 there were on the average 58,477,000 head of hogs (including pigs) on farms, but at the beginning of 1936 there were only 42,541,000 head. During the same interval horse and mule numbers on farms receded from an average of 21,539,000 to 16,322,000. Numbers of sheep and lambs, and of cattle and calves, however, increased. In the period 1924-1929 the total of sheep and lambs was 42,016,000 head, but the inventory on January 1, 1936, showed 51,690,000 head. The numbers of cattle and calves increased from 60,720,000

to 68,213,000 head. In the depression years, the number of cattle and calves reached a peak on January 1, 1934, and sheep and lamb numbers on January 1, 1932, although there was not much change in sheep and lamb numbers on the inventory date from 1931 to 1934. Some decrease has occurred since these high points were reached, particularly in cattle and calves.

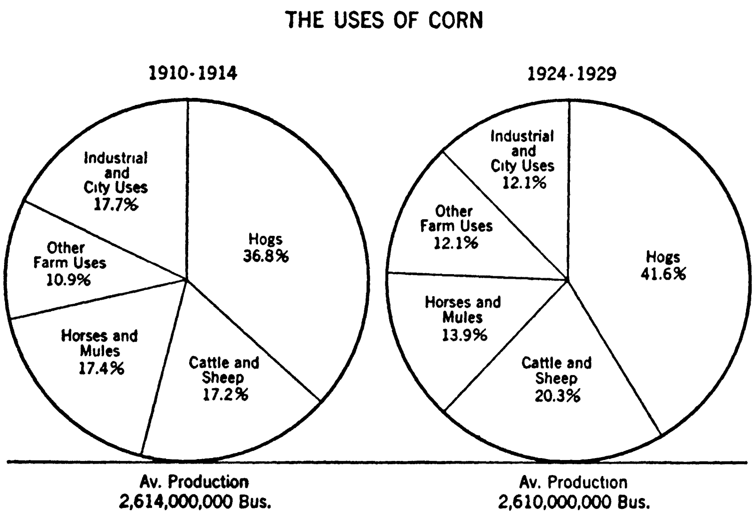


FIG. 99.—More than three fourths of the United States corn crop is fed to livestock.

Although the most important use of corn is for livestock feed, large quantities are used on farms for food and in industrial plants. On the average, slightly more than 30,000,000 bushels of corn are used annually for food on farms where corn is grown. The consumption is greatest in the southeastern states, although large quantities are also used in the Southwest. Only nominal amounts are used on the average in other

states. A considerable amount of corn is also eaten in the form of corn meal in urban centers. It is used much less than wheat flour as a food, however, partly because of a change in consumer diets from the starchy types of food to other types. The industrialization of the South, the sharp shift away from corn bread as a war cereal, and the displacement of home baking by commercial baking were factors in the reduced consumption of cornmeal.

TABLE XVII

CORN: UTILIZATION, 1910–1914 AND 1924–1929

Use	1910–1914 Inclusive	1924–1929 Inclusive	Increase or Decrease
	Million bushels	*Million bushels*	*Per Cent*
Horses and mules on farms	455	362	−20 4
Cattle on farms	424	505	+19.1
Hogs on farms	963	1085	+12.7
Sheep on farms	26	26	0.0
Poultry on farms	235	270	+14.9
Livestock not on farms	183	65	−64.5
Industrial and commercial utilization	235	230	− 2.1
Exports	44	23	−47.7
Families on farms	31	26	−16 1
Seed	18	18	0 0
Total	2614	2610	−0 2

The use of corn grits by the brewing industry was curtailed during the prohibition period, but has increased with relegalization. A smaller quantity of corn and corn products is now used in making each barrel of fermented malt liquor than befor the War. The wet-process corn industry—makers of

starch, syrup, sugar, and oil—increased its output of products during 1920-1929, but the depression and the competition of certain substitutes limited the grind of corn in the years 1930-1933. Generally speaking, the grind of corn depends very largely on business activity. Within reasonable limits the price of corn is not a significant factor in influencing the quantity of corn which may be processed into the multitude of items merchandised by this industry. It might be pointed out that as long as a reasonable relationship or ratio is obtained or permitted between each corn product and its competitor, or at least between the principal corn products and their respective competitor or competitors, the price of corn is not a material factor influencing the grind.

The relegalization of alcoholic beverage production in 1933 increased the commercial use of corn. The Act of March 22, 1933, effective April 7, 1933, authorized the manufacture of fermented malt liquor (beer) containing not more than 3.2 per cent of alcohol by weight. A proposed amendment to the Eighteenth (prohibition) Amendment of the Constitution was transmitted by Congress to the Secretary of State on February 21, 1933, and he at once sent to the governors of the states copies of the resolution. The amendment went into effect on December 5, 1933, having been adopted by three-quarters of the states. In the fiscal year 1935, about 341,000,000 pounds of corn and corn products were used in the manufacture of fermented malt liquors compared with 257,000,000 pounds in the fiscal year 1934 and only 57,000,000 pounds in the fiscal year 1933. Large quantities of corn were used in making alcohol and distilled spirits. In the fiscal year 1935, more than 19,000,000 bushels of corn were used in the manufacture of ethyl alcohol and distilled spirits compared with less than 6,000,000 bushels in 1932-1933.

TABLE XVIII

UTILIZATION OF CORN AND CORN PRODUCTS FOR HUMAN FOOD AND INDUSTRIAL USES, IN TERMS OF CORN GRAIN, 1919–1920 TO 1934–1935

Year	Farm Consumption of Corn Meal *	Corn-Meal and Flour Production †	Wet-process Grindings ‡	Breakfast Foods §	Alcohol and Distilled Spirits ‖	Total, Excluding Farm Consumption of Corn Meal
	1000 bushels	*1000 bushels*	*1000 bushels*	*1000 bushels*	*1000 bushels*	*1000 bushels*
1919–20	33,823	53,415	66,549	......	1,058	....
1920–21	32,955	.....	50,689	......	4,811	....
1921–22	32,088	54,661	68,069	......	3,093	....
1922–23	31,219	......	65,875	......	3,106	....
1923–24	30,347	60,776	75,635	......	4,835	....
1924–25	29,478	..... .	68,232	......	7,201	. ....
1925–26	31,000	49,340	83,347	9,544	7,948	150,179
1926–27	30,956	......	83,048	......	8,383	......
1927–28	30,919	49,704	87,203	12,759	6,189	155,855
1928–29	30,877	......	88,198	......	9,802	.. ....
1929–30	30,840	55,975	77,490	16,690	9,966	160,121
1930–31	30,840	......	66,554	......	2,454	.. ...
1931–32	30,840	44,660	62,002	16,138	4,848	127,648
1932–33	30,840	......	72,100	.. ...	5,818	......
1933–34	30,840	44,606¶	69,896	13,574	10,362	138,438
1934–35	30,840	......	56,004	.. ...	19,400	......

Compiled by Bureau of Agricultural Economics.

* Estimated quantities of corn meal used for household purposes on farms where corn was grown. Data for year beginning November.

† Production of corn meal and corn flour as reported by Bureau of Census converted to the estimated equivalent of corn grain. The proportion of degermed and non-degermed corn meal is not known. It is assumed, however, that 5 bushels of corn were required to make 1 barrel of corn meal and 6 bushels of corn to make 1 barrel of corn flour. Data are for the odd-numbered calendar years.

‡ Corn used in the production of starch, syrup, sugar, oil, and other derivatives of corn. Data are for the year beginning with November.

§ Estimated from the Census of Manufactures, Bureau of the Census. It was assumed that 23 pounds of the product were obtained from 1 bushel of corn. Data available only for odd-numbered calendar years.

‖ Compiled from records of the Bureau of Internal Revenue, Department of Treasury. Data are on a fiscal-year basis, beginning July 1.

¶ Figure obtained by applying the ratio between the 1933 production as reported on the standard schedule and the 1931 production figure comparable with 1933, to the 1931 production figure as published, which was comparable with the earlier years. Corn flour figure not yet available for 1933.

SELECTED LIST OF REFERENCES

LEIGHTY, C. E., WARBURTON, C. W., STINE, O. C., and BAKER, O. E. The Corn Crop. U. S. D. A. Yearbook. 1921.

TAYLOR, A. E. Corn and Hog Surplus of the Corn Belt. Stanford U. Press. 1931.

ANONYMOUS. Use of Alcohol from Farm Products in Motor Fuel. Senate Doc. 57, 73rd Cong. 1933.

CHAPTER XXII

ECONOMIC FACTORS AFFECTING CORN PRICES

CORN prices ultimately are determined by the price consumers are able and willing to pay for hogs. It is for this reason that over a period of years there is a fairly definite relationship between the price of corn and the price of hogs. On the average, for the country as a whole, the price of about 23 bushels of corn at the farm is equal to the price of a 220-pound hog, and the hog-corn ratio has thus fluctuated around 11.5 bushels.

Both the relation of consumer purchasing power to the price of hogs and the effect of variations in the hog-corn ratio on hog production are discussed in the next chapter.

Although corn prices in the long run depend upon consumer income and hog prices, they also are related to the general commodity price level and to the short-time changes in supply and demand. Sharp changes in the general level of wholesale prices and in the purchasing power of the dollar—the rapid advance in prices during the World War and the declines at the close of the War and during the period 1930-1932—are quite familiar. These wide fluctuations in prices in general reflect the widely changing monetary and business conditions of the country. Generally speaking, when factors that influence all prices force the average level of all prices upward, corn prices advance. When the price level shifts to a lower position, corn prices tend downward. This is clearly revealed in Fig. 100, where Chicago corn prices and the index of commodity prices in general are shown for the period 1890 to 1935.

We see here that the general commodity price level is the most important factor in the price of corn over a long period, such as that of 1890 to 1935. Over short periods, such as the few years before the World War and the post-war years, 1923-1929, when the general commodity price level tended to remain relatively stable, other factors are chiefly responsible for the year-to-year price fluctuation. By far the most important item is the annual corn crop.

The annual fluctuations in corn prices shown in Fig. 100 for Chicago are similar to the fluctuations in other central markets and in practically all corn-producing areas.

Since the cash grain areas and also the heaviest corn production are in the Corn Belt, it is obvious that the United States farm price of all classes and grades of corn should closely fluctuate with a representative grade of corn in a market receiving a large proportion of the total receipts. Generally speaking, the price of No. 3 yellow corn at Chicago fluctuates with the United States farm price of corn, although generally at a slightly higher level.

The price of corn varies widely over the United States. Lowest prices prevail in a circle of counties in northwestern Iowa, southwestern Minnesota, southeastern South Dakota, and northeastern Nebraska. Low prices are also evident throughout the areas of heaviest production—from western Ohio through the greater part of Nebraska. From this area, prices attain higher levels toward all points of the compass, but at varying degrees of increase. The highest prices are usually obtained in the markets farthest from the Corn Belt—the coastal markets, and parts of the far southwest (Fig. 101).

Although corn prices in corn surplus producing states are usually lower than prices in deficit areas by the amount of freight and other marketing differentials, variations in production by states bring about alterations in the relation of prices among the several states. In years of severe shortages in surplus producing states as in 1934 the usual direction of

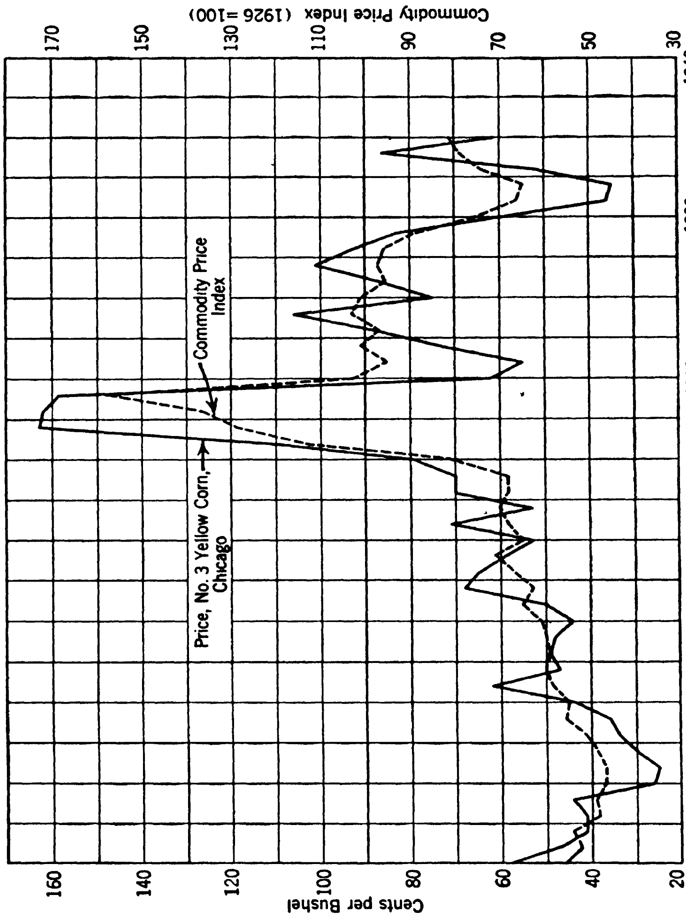


FIG. 100.—Corn prices rise and fall with the general level of commodity prices.

flow of corn to central markets may alter and corn be shipped into normally surplus areas. Prices in the normally surplus areas may then actually be higher than in the normally deficit areas. For example, corn prices in South Dakota are usually below those of Pennsylvania and Rhode Island, but in 1934 they exceeded the prices in the deficit eastern areas. The variations in local supplies are largely responsible for the fact that the prices do not show a constant margin of difference.

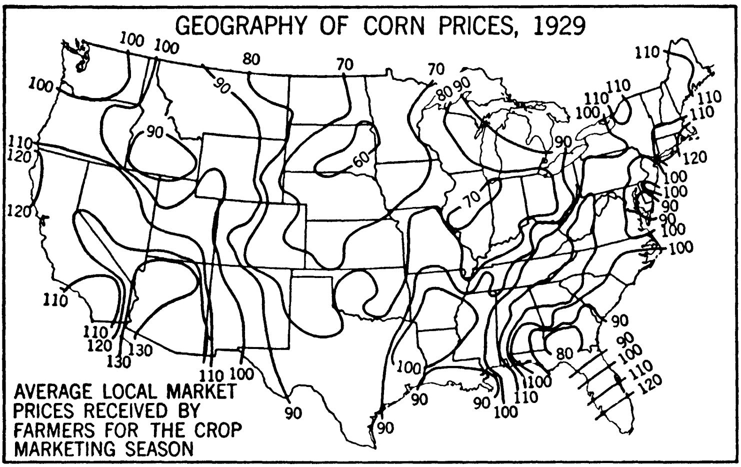


FIG. 101.—Corn prices are low in the Corn Belt and high in the Coastal States.

The range in corn prices throughout the United States normally amounts to as much as 100 per cent from the lowest to the highest prices recorded. This is accounted for by variations in the intensity of production and the local demand for corn. In the western Corn Belt states, from which corn crop surpluses must move great distances to market, local corn prices ordinarily are at a relatively lower level than in any other part of the country. From this area of intensive cultivation and surplus production of corn, prices rise in every direction, reach-

ing their peak in the desert regions of western Arizona, where very limited quantities are grown on irrigated farms.

The geographical variation of corn prices received by farmers in a single year (1929) is illustrated in Fig. 101. This presents the local market price picture for 1929 with *isotimes*, or lines of equal price, depicting the differences in prices received, just as isotherms, or lines of equal temperature, are employed to show variations in temperature on a weather map. In 1929, the lowest prices received by farmers for corn were registered in eastern South Dakota, where a favorable season produced a larger-than-average crop. The surplus moved to market at an average price of approximately 60 cents per bushel.

The local nature of the corn market is amply illustrated by the variations in the price pattern for the 1929 season. Industrial users consume only part of the surplus produced in the west north central states. In consequence, prices rise as one proceeds not only from Iowa to Chicago, but also from Chicago to the south and east towards sections producing less corn than is needed as feed for livestock. Similarly, higher prices are found to the west of the Corn Belt.

As these deficits occur in greater or lesser intensity, so also do prices rise and fall. Corn prices were low in 1929 in southern Louisiana, southern Georgia, and the eastern shore of Maryland compared with surrounding territory, largely because of local surpluses. On the other hand, localized price plateaus may occur in a particular year as the result of an unfavorable growing season. This happened in Arkansas in 1929. Price plateaus also occur in areas where normally a surplus is produced, as in Nebraska and South Dakota during the great droughts of 1933 and 1934. Corn is thus particularly responsive to local supply and demand conditions. It is a crop that is largely used for feed on the farms where grown, or on neighboring farms, and as such is marketed in the form of livestock or livestock products.

The geographical differences in corn prices in the post-war years were very much like those of the pre-war years, as may be seen from Table XIX.

TABLE XIX

FARM PRICES OF CORN IN SURPLUS AND DEFICIT PRODUCING STATES, 1909–1913 AND 1924–1928

	1909–1913 *cents per bushel*	1924–1928 *cents per bushel*
Rhode Island	92	126
Maine	81	115
Pennsylvania	66	92
Iowa	47	68
South Dakota	47	63
Nebraska	49	71
South Carolina	89	104
Mississippi	73	99
Texas	73	85
Arizona	103	123
United States	57.2	75.5

The price of corn also fluctuates with the price of other feed grains, and likewise with that of wheat. Production of corn is so large compared with that of other feed grains that it is a very important factor influencing the prices of other feed grains. Of course, monetary and financial conditions in general affect all prices. Corn prices increased sharply compared with barley after about 1885, and compared with oats after about 1910. In the years from about 1870 to 1900, corn prices were about one-half as high as those of wheat, but since 1900 the price of corn has been about 60 per cent of the price of wheat.

ANALYSIS OF FLUCTUATIONS IN CORN PRICES

Farmers and others who are concerned with corn need to make intelligent guesses as to the level of corn prices some time in the future. In planning the next year's crop one of the important considerations is the probable price at harvest time. Once the crop is harvested many farmers try to figure on the probable course of corn prices during the marketing season before the next crop becomes available.

The prices on the Chicago Board of Trade and other grain exchanges sometimes give a clue as to probable price trends, but even though the professional speculators on these futures markets watch all the current and prospective changes in supply and demand conditions, their dealings seldom give the kind of information farmers want considerably in advance. The prices paid for corn to be delivered some time in the future, even though traders were convinced that very marked changes in supply and demand would prevail a year later, are to a large extent dependent upon the price of cash corn, which in turn is dependent upon current supplies and current demand conditions. The more distant factors are therefore not adequately reflected in either the current cash or current futures prices.

(A) Year-to-Year Changes in Corn Prices

Certain broad facts may be utilized in judging year-to-year changes in corn prices and the changes during the marketing season. The year-to-year fluctuations are, of course, influenced by a large variety of factors such as variations in supply, in the number of feed animals, in demand for commercial grinding for human food, in foreign demand, in prices of competitive and substitute products, like oats, barley, and wheat, financial conditions, domestic and foreign crop conditions, and

a number of others; Fig. 102 shows the extent to which corn prices at times fluctuate with the prices of wheat and oats. Actually only about four items of major importance are needed to obtain a clue as to probable year-to-year changes, say in the December price of No. 3 yellow corn at Chicago.

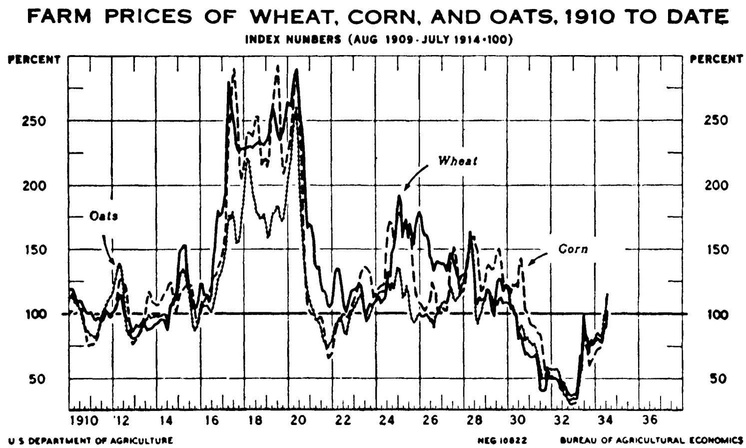


FIG. 102.—Corn, wheat and oats having common uses as foods and feeds, their prices are often affected by common factors.

The variations in the December price of corn can be very largely explained by the chief item of supply, namely, the annual crop; the chief item in demand, namely, the number of hogs and of cattle on farms; and the general price level, which may be taken to represent prices of competing and substitute commodities as well as financial and industrial conditions, for as general business conditions change sharply they have an immediate effect on the general commodity price level. The problem may be simplified by combining the two chief items of supply and demand, the corn crop and the number of hogs on farms, into one item of production per hog on farms. The 1934 corn crop was only 1,377,000,000 bushels, and the number of hogs on farms in January, 1935, was only 39,000,000, or

35.3 bushels per hog. The 1935 corn crop was 2,209,000,000 bushels, and the number of hogs on farms on January 1, 1936, was 42,500,000, or 52 bushels per hog. In the ten years 1926-1935 the corn production per hog has been as low as 35 bushels. During this period the basic relation between new corn production per hog on farms and the December price of No. 3 yellow corn at Chicago has been as follows:

TABLE XX

RELATION OF CORN PRODUCTION PER HOG ON FARMS TO CORN PRICES

Corn Production per Hog on Farms	December Price No. 3 Yellow Corn, Chicago
bushels	*cents*
34	98
36	89
38	80
40	72
42	66
44	62
46	58
48	56
50	54
52	52

This quantity-price relationship is based on the 1935 general commodity price level of 80 per cent of that of 1926. It also represents the effect of new production available per hog on the assumption that the number of cattle and calves on farms remains at 65,000,000 head. Since neither of these factors remains fixed, it is necessary to know their separate influences on corn prices in addition to the effect of supply per hog.

The experience of the ten years including 1935 indicates the following effect of the price level on December No. 3 yellow corn prices at Chicago.

This table is to be used in connection with Table XX. In December, 1935, the price of No. 3 yellow corn at Chicago was about 60 cents and the general commodity price level was about 80 per cent of the 1926 level. An increase in the price

TABLE XXI

RELATION OF PRICE LEVEL TO CORN PRICES

Index of Commodity Prices, 1926 = 100 Per Cent	Percentage Addition to or Subtraction from Corn Prices (*percentage of prices in Table XX*)
65	− 60
70	− 40
75	− 20
80	0
85	+ 20
90	+ 40
95	+ 60
100	+ 80

level from 80 to 85, with supply and demand conditions unchanged, would call for increasing the 60-cent price by 20 per cent, or an increase of 12 cents per bushel. Similarly, a drop in the price level from 80 to 75 would call for a 20 per cent or a 12-cent decline in the price of corn.

The third factor that has apparently had some influence on corn prices, though not at all as marked as the effects of supply and the price level, is the number of cattle on farms. The relationship based on the ten years, including 1935, is as follows:

TABLE XXII

RELATION OF CATTLE NUMBERS TO CORN PRICES IN CHICAGO

Cattle on Farms January 1 (*millions of head*)	Effect on Corn Prices (*percentage of prices shown in Table XX*)
57	− 20
59	− 18
61	− 15
63	− 10
65	0
67	+ 6
69	+ 11
71	+ 12
73	+ 12

The use of Tables XX to XXII in estimating corn prices may be illustrated by working out an actual example. In 1927, for instance, the corn crop was 2,678,000,000 bushels. The number of hogs on farms on January 1, 1928, was 61,900,000. The corn crop thus represented 43.3 bushels per hog on farms. According to Table XX, a crop of this size in relation to hog numbers is related to a price about midway between 66 and 62 cents, or about 64 cents. This price now needs to be increased or decreased according to the effect of the price level for that season and the number of cattle on farms. The price level for December, 1927, was 96.8 per cent of the 1926 average, and, according to Table XXI, this is related to an addition to corn prices of about 68 per cent. Similarly, the number of cattle on farms on January 1, 1928, was 57.3, and according to the relation in Table XXII, a relatively small cattle demand for corn tends to reduce corn prices by about 20 per cent. The net effect of these two factors combined, an increase of 68 per cent for the relatively higher price level and a decrease of 20 per cent due to the small number of cattle, is an increase of 48 per cent to be added to the estimate of 64 cents derived from Table XX. This net increase is 31 cents, making a total price 95 cents. The actual price of No. 3 yellow corn in December, 1927, was 95 cents.

In practice, of course, producers during the planting and growing season need to make forecasts or guesses as to the outturn of the crop, the probable number of hogs and cattle on farm for the following year, and the probable level of commodity prices in general. This information is difficult to obtain and at best is an intelligent appraisal of future events, but much helpful material can be obtained from the federal and state agricultural agencies, in the way of prospective crop, price, and demand conditions.

B. The Seasonal Variation in Corn Prices

The corn season.—The corn season begins at different dates in the United States, depending upon the type of harvest and the section of the country referred to. For instance, the cutting of silage begins in the southern part of the Corn Belt in the latter part of August and first week of September and is general by the middle of September. Cutting and shocking, which is a common practice in the dairy states of the north and in Ohio, northeastern Kentucky, West Virginia, and most of Virginia and Maryland as well as in the eastern Ozark region of Missouri, begins between September 1 and 20, and is general from Iowa eastward during the last ten days of September. Husking and jerking starts in the southern states during September and becomes general during October. In the heart of the Corn Belt jerking from the standing stock begins during the latter part of October and continues into December.

Information regarding the corn crop and the probable carryover of old crop corn is of course available long before the beginning of the season in which the supply may be marketed. If toward the close of a season of comparatively large supplies it becomes evident that only a very short crop is in prospect, either because of a reduction in acreage or a low yield, prices of corn on the farm and in the market will advance to a level commensurate with the prospective supply and demand conditions. Similarly, at the close of a season of short supplies, prospects might point toward a larger acreage and possibly a larger supply for the coming season; prices will tend downward to the larger supply basis before the crop moves to market.

In measuring the seasonal trend of prices of corn it would appear necessary to start at some point in the season where the influence of new crop developments are first noticed and extend to that point where the supply is no longer the impor-

tant factor in making prices. The crop for any particular year affects the price for more than twelve months. During July, August, September, and October, and even into November and December, the price of corn is determined by the crop of the year as well as the crop to be harvested that fall and early winter. However, the influence of the current supply situation begins to lose its effect on prices in July, August, and the subsequent months, with new crop influence increasing in importance as price-making factors.

Seasonal price changes and changes in the corn crop.—In view of the overlapping influences of old and new crops on the seasonal behavior of corn prices it would seem reasonable to find certain outstanding characteristics in corn price changes during the course of a year depending on whether the season in question is one of a normal, large, or small crop and whether it follows a normal, large, or small crop. An examination of the seasonal prices of No. 3 yellow corn in Chicago indicates that a very useful classification is the simple one according to whether the crop for the year in question shows a large increase, moderate average increase, little change, moderate decrease, or large decrease. A large increase or decrease is about 800,000,000 to 1,000,000,000 bushels, judging from the experience of the forty years, 1895 to 1935. An average or moderate increase or decrease is about 400,000,000 to 600,000,000 bushels. An increase or decrease in the crop of about 50,-000,000 to 100,000,000 bushels may be taken as showing little change.

Reference to Table XXVII will show which years may be considered as belonging to each of these five crop situations. The years 1900, 1906, 1908 and 1927 are years of little change, and therefore the average behavior of corn prices in these and similar years may be taken as approximately the usual seasonal course.

If we express the prices in each of these crop years from April to June of the following year as percentages of the

December price for each year and make allowance for the effects of changes in the general commodity price level (by dividing the monthly prices by the commodity price index) and then average the prices of the corresponding months of these seasons together we obtain the course of prices as shown in Fig. 103 marked "year of little change." We thus have an indication of the typical price changes (1) before the size of the new crop becomes known, (2) during the months of heavy marketing October to February, and (3) from February to June. Up to about July, prices tend upward continuing the tendency for corn prices to average higher after the months of heavy marketings. On the average, farmers market their crops as follows:

	Percentage of Yearly Marketings
October	7.5
November	9.8
December	12.8
January	11.1
February	9.8
March	7.4
April	6.0
May	6.5
June	7.0
July	7.1
August	7.9
September	7.1
Total	100.0

By December, in response to the increased marketings, corn prices tend to decline from about 20 per cent between August and December. Thereafter a gradual rise sets in amounting to about 20 per cent in June over the previous December price.

This characteristic seasonal pattern of price change becomes distorted in years of large or moderate increases in production. It is as if the early part of the seasonal pattern were tilted upward and the later part tilted downward so that the

price decline from July to December is increased and the usual rise after December is decreased.

The years of large crop increases since 1894 were 1895, 1902, and 1935, and corn prices followed about the same course in each instance. The decline in this type of year tends to set in earlier, about June or July, and by December has amounted to 35-40 per cent. The seasonal advance thereafter is only about half normal.

In the years when there was a moderate increase in corn production prices declined about 33 per cent between June and December and very little seasonal advance on the average appeared after January 1. The years included in this group are 1905, 1912, 1915, 1920, 1925, and 1931. Although all show the more than usual decline up to December, the behavior of prices after December was not as consistent in each of these six years as in the other two groups of years, and, therefore, the small seasonal rise after December for years of moderate increase in the corn crop may be somewhat understated. For three of these seasons (1905, 1912, and 1920) June prices averaged about 20 per cent above December prices, and for the other three years June prices averaged about 7 per cent below the December prices.

The typical price developments in years of decreased production are shown in the lower part of Fig. 103. In 1901 and in 1935 the corn crop was very sharply reduced, and the course of prices was almost identical in each season. After July and August, prices tended upward and reached a peak in December, just as in the comparable years of large increases in production prices fell to their low point in December. The advance between June and December amounted to nearly 50 per cent. Apparently there was in both of these short-crop seasons a tendency for the price advances to exceed the basic level warranted by supply and demand conditions in December, for they thereafter tended slightly downward, contrary to the usual seasonal tendency.

The years of moderate crop decreases (1897, 1907, 1911, 1913) show a rising price tendency up to October, the advance between June and October being about 35 per cent; a declin-

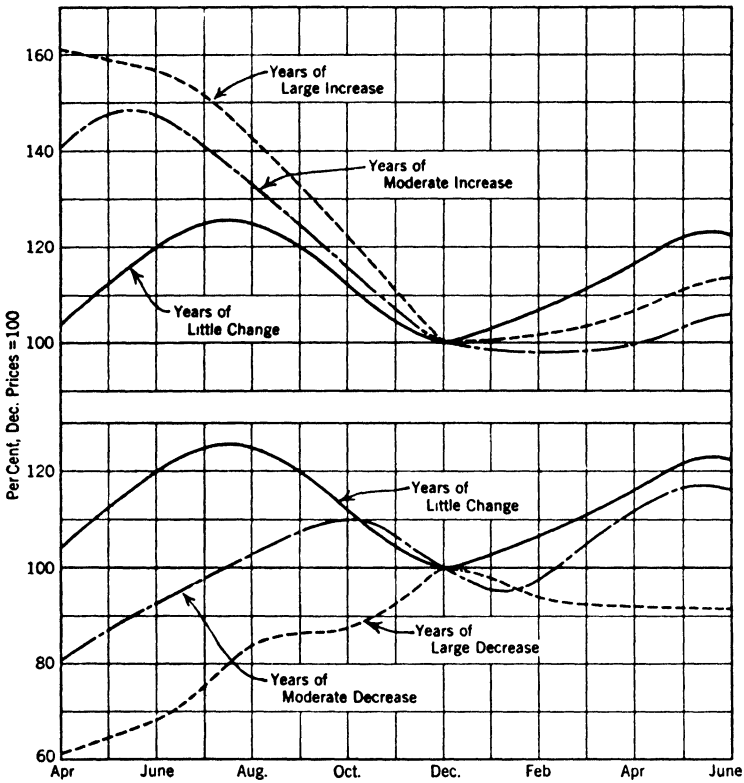


FIG. 103.—Large increases in the size of the corn crop from year to year cause large declines in price, and large reductions in the crop cause marked increases in price between June and December.

ing tendency from October to January, the decline amounting to about 15 per cent; and again a rising tendency between January and May, this rise amounting to nearly 20 per cent.

From these typical cases we may generalize as follows: Normally corn prices at Chicago decline about 20 per cent between August and December and advance about as much between December and May. In years of marked increases in production the decline from June to December is nearly 40 per cent and the advance between December and the following June about 10 to 15 per cent. In years of moderate increases in production the decline from June to December is about 30 per cent and the advance between December and June about 5 to 10 per cent. In years of marked reductions in the corn crop, prices advance nearly 50 per cent between June and December and tend to decline slightly thereafter, whereas in years of moderate reductions in the crop, prices advance about 20 per cent between June and October, decline about 15 per cent between October and January, and then advance about 20 per cent between January and June.

C. Marketings and Seasonal Price Trends

Monthly corn price changes are subject to a large number of influences, such as actual and prospective changes in supply, changes in domestic demand, changes in the supply and prices of competing and related products like oat, wheat, and hogs. The variations in farmers' marketings and in market receipts constitute one of the important items that cause the seasonal trend of corn prices to vary from the patterns discussed in the foregoing pages. The relation between prices and marketings is a double-way relation. An increase or decrease in marketings by farmers from the normal volume for any month causes prices to fall or rise, but a rise or fall in prices also tends to stimulate or retard the flow of corn to country elevators and to central markets. For example, the year-to-year variations in the Chicago price of corn for December causes corresponding changes in the rate of marketings by farmers during the following month. This effect of price on farmers' marketings

of yellow corn is clearly indicated by the data for the period 1924-1932. Farmers shipped nearly 14 per cent of their yearly marketings in January when prices averaged about a dollar per bushel, in 1927-1928 and 1924-1925, but only 8 per cent in January 1932-1933, when prices had fallen to less than 30 cents.

Variations such as these in the farmers' rate of marketings, largely to local elevators, cause variations in the receipts

PRICES OF DECEMBER No. 3 YELLOW CORN, CHICAGO

	Cents	*Percentage Marketed in January*
1932–33	28	8.0
1931–32	35	10.2
1930–31	63	11.0
1926–27	74	11.7
1925–26	75	12.1
1929–30	83	10.9
1928–29	90	12.9
1927–28	95	13.8
1924–25	116	13.6

of corn at the terminal markets. The effect of prices on terminal receipts can be readily illustrated by examining the data for years of about the same corn production. The corn crops of 1926-1929 inclusive and 1931 were about the same size and about average, ranging between 2,500,000,000 and 2,700,000,000 bushels. Had prices likewise been about the same for each of these five years marketings would also have tended to be fairly constant. Actually, receipts at eleven terminal markets were as high as 294,000,000 bushels in 1927 when the corn crop was less than 2,700,000,000 bushels and as low as 141,000,000 bushels in 1931 when the corn crop was slightly under 2,600,000,000 bushels. This difference in the volume marketed is largely a

matter of price variations due to general business and agricultural conditions, as is suggested by the following example:

Season	Price of Corn No. 3 Yellow, Chicago	Corn Receipts at 11 Markets
	cents per bushel	*million bushels*
1927–28	101	294
1928–29	92	267
1926–27	87	221
1929–30	83	235
1931–32	36	141

This record indicates than an increase or decrease in price of about 20 cents per bushel is accompanied by an increase or decrease of about 50,000,000 bushels in receipts at the eleven markets.

D. Corn Prices and the Volume of Speculation

It is often said that the price of corn is determined by the speculators in the corn pit of the Chicago Board of Trade. This can be true only in a limited sense. By and large the yearly price of corn varies in accordance with the basic factors of supply, demand, and general monetary and business conditions. Speculators are constantly evaluating these price forces, and only in limited periods of perhaps a few days or weeks can a speculative market pull prices away from the level called for by these supply and demand conditions. As a matter of fact, supply and demand conditions determine price changes and price changes determine to a large extent the volume of speculative trading. This is true not only of corn but also of wheat, cotton, and other commodities dealt with in the speculative markets.

Take for example the three crop years 1924-1926. The small corn crop of 1924, of 2,298,000,000 bushels, produced ris-

ing and high prices, the average of No. 3 yellow corn at Chicago for the season being $1.06. The volume of corn futures traded in amounted to 6,841,000,000 bushels, chiefly at Chicago. This was about three times the size of the corn crop. In 1926, the corn crop was larger, 2,575,000,000 bushels, the price lower at 87 cents, and the volume of futures trading was also smaller, 6,394,000,000, about 2½ times the size of the crop. But in 1925 the crop was fairly large, 2,853,000,000, the price fell to 75 cents and the volume of speculator trading fell to 4,153,000,000 bushels, or only about 1½ times the size of the crop. Taking an entire season into account, it is not speculative activity that determines price changes, but rather price changes and prospects of price changes that bring about a large or small volume of speculative activity.

Weather and corn prices.—Since the size of the crop has far more to do with corn prices than all the other factors put together, it is especially important to study the weather in its relation to the size of the crop. This is considered in great detail in Chapter XXIV. Suffice it to say here that the all-important features from the standpoint of corn prices are the rainfall and temperature from July 1 to August 20. During this period, it requires an average of about 1 inch of rainfall every ten days to hold new crop futures (December and May) corn prices steady. More than 1 inch of rainfall in ten days tends to lower corn prices, 1.4 inches or more tending to cause a drop of 2 or 3 cents a bushel. Less than half an inch of rainfall in ten days tends to cause an advance of 3 or 4 cents a bushel. If there has been an average of less than a tenth of an inch of rain during the ten-day period, and if the mean temperature has averaged above 80°, the corn price may run up 6 to 8 cents a bushel. To determine the average rainfall, it is necessary to have reports from at least twenty representative stations in each of such states as Iowa, Illinois, Indiana, Ohio, Missouri, Nebraska, and Kansas. The Illinois, Indiana, and Missouri stations are most important. The daily corn and

wheat region bulletin, which may be obtained from the Chicago Weather Bureau, gives such information. Occasionally, unusually cold or wet weather in May and June will advance the speculative new crop futures very materially, as it did in 1927. As a rule, June weather has very little effect on new crop corn futures, but if the weather has been exceptionally dry during the spring, a widespread June rain may break December corn futures by 5 cents or even more per bushel, as during the third week in June of 1925.

Once in a long while a killing frost in September or early October may cause December corn futures to rise, but in general the possibility of frost damage has been discounted in advance because it has been known for some time that the crop was backward and likely to be damaged by frost. Perhaps once in five or six years early fall frost may have a little influence on price of December corn futures.

In the typical season, the outstanding features of the weather influencing the size of the new corn crop and the price of new crop futures are the rainfall and temperature in July and early August.

The behavior of corn prices during the drouths of 1934 and 1936, paralleling the price experience of earlier drouths such as 1901 and 1894, reveal clearly the relation of weather to corn prices. A spring season that starts with abnormally high temperatures and abnormally low rainfall is fairly certain to bring rising corn prices.

GOVERNMENT CROP REPORTS

The first government crop report relating to corn is the intentions-to-plant report issued during the latter part of March each year. Some 40,000 farmers, well distributed over the United States, report the acreages of the various crops on their own farms for the year before and also the acreages they expect to plant in the current year. When these reports are summarized, and interpreted by the Crop Reporting Board on

the basis of past experience with this inquiry, a very good idea is obtained of the number of acres that are likely to be planted to corn if weather permits. Generally adverse weather during planting time would result in a smaller corn acreage than indicated by the March intentions report. This report, however, enables individual farmers to adjust their own farming plans in the light of what farmers generally are expecting to do.

The government's crop report issued about July 10 each year includes an estimate of the acreage planted to corn and a forecast of the probable yield per acre and total production. The estimate of acreage is based on reports from approximately 60,000 farmers. These reports are similar to the ones made in March on intentions to plant.

The July forecast of yield per acre is based on a statistical interpretation of the condition of the growing crop on or about July 1, as reported by approximately 20,000 crop correspondents from all parts of the United States. These correspondents are mostly farmers, and all serve voluntarily and without pay. On the first of each month during the growing season they send in reports to the Department of Agriculture. They express their judgment in a figure representing what percentage they estimate the corn will yield of "normal." From the way the system works out in practice, the crop reporters appear to look on the word "normal" as meaning a crop which is somewhat above average but not perfect. From 1866 until 1912 the Department published these crop condition figures but made no forecasts of probable yield per acre. In response to popular demand, in 1912 the Crop Reporting Board began to make forecasts of crop production during the growing season. The crop condition figures were translated into terms of probable yield per acre by the use of the "par" method. This method involved the application of a formula, based on simple arithmetic proportion, which may be stated as follows: The ten-year average condition for a given month is to the condition reported for that month of the current year as the ten-year average yield

per acre of corn is to the probable yield in the current season. The July estimate of acreage is applied to the forecast of yield in each successive monthly report in making a forecast of total corn production.

About 1930 a more statistically reliable method was adopted in making forecasts during the growing season. This method is based on the usual or average relationship shown of the reported condition figure to the final yield obtained over a period of years. For example, if the July 1 condition of corn is reported by crop correspondents to be approximately 80 per cent of normal for a given state, the forecast of yield will be approximately the average yield obtained in previous years when the condition was reported as about 80 per cent. The interpretation makes allowance for any pronounced trend or change in the relationship of reported condition to final yield per acre. In the language of the statistician, graphic correlation technique is used in interpreting the reported condition.

A change in the method of forecasting was made necessary because in some states with certain crops a high condition during the growing season was followed by low yields at harvest, and a low condition was followed by high yields—just the reverse of what one would naturally expect. Potatoes in Maine and wheat in Maryland and other eastern states furnish instances in which this inverse relationship exists between the reported condition and the final yield of a crop.

The probable yield per acre of corn is forecast in connection with the government's crop report on or about the tenth of each month from July to October inclusive. On November 1 crop correspondents report their estimate of the average yield of corn per acre in their localities. In October, with the help of rural mail carriers, a survey is made in every state of the acreages of all crops harvested. A very large sample is obtained covering approximately 160,000 farms in the United States. An estimate of the acreage harvested, the yield per acre, and total production of corn is published in the December

crop report. The acreage estimate is based largely on an interpretation of the returns from the rural carrier survey, together with other acreage information, such as assessors' enumerations, crop meter measurements, etc.

The crop reporting service has been developed in response to a continuous and insistent demand for unbiased agricultural information which no other agency has been able to supply. For years before official crop reports were issued, there was considerable agitation on the part of farmers for accurate information regarding crop production before their crops had gone to market. Even prior to 1839 farmers resented the profits made by dealers and speculators in farm products as a result of the circulation of misleading crop reports. During the 1850's several farm papers and county and state agricultural societies endeavored to meet this need for current information on crop production. Finally in 1866 regular monthly reports on the condition of crops during the growing season and annual reports on acreage, yield per acre, and total production of important crops, and numbers of livestock on farms January 1, were begun by the newly formed Department of Agriculture. Even in the early years of the organization information concerning the production of crops and livestock in foreign countries was obtained and published regularly by the Department. The monthly crop report gives farmers, dealers, and speculators alike information concerning crop prospects and production, and thus places them all on an equal footing.

Influence of shrinkage and time of year.—Illinois and Iowa experiments indicate that, on the average, corn picked early in November will shrink about 3 per cent during November, 2 per cent during December, 1 per cent in January, 1 per cent in February, 1 per cent in March, 3 per cent in April, 3 per cent in May, 2 per cent in June, and 1 per cent in July, normally a total of about 17 per cent shrinkage from cribbing time in November until the middle of the following summer. Of course, there is considerable variation in the years. If the fall is dry and the corn is unusually well matured, the shrinkage

may amount to only 9 or 10 per cent, whereas in wet, cold falls the shrinkage may be as high as 25 per cent. The monthly figures represent normal conditions. In some years, however, the really heavy shrinkage will start in late March, in other years in April, and occasionally not until June. Ordinarily, though, late April and May is the time of the heaviest shrinkage in corn, much depending, however, on the temperature and the humidity.

On the basis of shrinkage alone, it would take, to equal a price of 50 cents a bushel for corn in November, a price of 55 cents in April and 58 cents in July. When interest is added at 6 per cent, and allowance is made for the overhead investment in the crib, and for a small amount of rattage, it will be found that in the ordinary year it will take, to equal a price of 50 cents a bushel for corn in November, about 52 cents in December, 53 in January, 54 in February, 55 in March, 57 in April, 59 in May, 60 in June, 62 in July, and 62.5 cents in August. The actual pre-war normal price for corn on Iowa farms was 49 cents a bushel in late November and December, 50 cents in January, 51 in February, 53 in March, 56 in April, 59 in May, 61 in June, 63 in July, 63 in August, and 61 cents in September. This would indicate that, before the War, it was normally a good plan to sell corn in late November, if possible, rather than to sell in December, January, February, or March. Rather than to sell in these months, it seemed usually to be a good plan to hold for a June, July, or August market.

SELECTED LIST OF REFERENCES

SHEPHERD, G. S. The Bumper Corn Crop Surplus. Iowa Cur. Ec. Series Rpt. 4. 1926.

COX, R. W. Factors Influencing Corn Prices. Minn. Tech. Bull. 81. 1931.

SHEPHERD, G. S. The Secular Movement of Corn Prices. Iowa Research Bull. 140. 1931.

——. Annual Fluctuations in the Price of Corn. Iowa Research Bull. 164. 1933.

Anonymous. Crop and Livestock Reporting Service of the U. S. U. S. D. A. Miscel. Pub. No. 171. 1933.

CHAPTER XXIII

THE INTERRELATIONSHIP BETWEEN CORN AND HOGS

SINCE about 40 per cent of the total corn crop is usually fed to hogs, and since the principal hog feed is corn, there is a very close relationship between corn production and hog production. This close relationship is illustrated in Figs. 104 and 105, which show the acreage of corn and the number of hogs in the various states of the nation. The marked concentration of both hogs and corn in the Corn Belt, especially Iowa, southern Minnesota, eastern Nebraska, southeastern South Dakota, northern Missouri, northern Illinois, northern Indiana, and northwestern Ohio, is very noticeable in these two figures.

In no other region of the world with the possible exception of the Danube Basin of Europe are hogs and corn so closely interrelated as they are in the Corn Belt of the United States. In most other important hog-producing countries, notably Denmark and Germany, hogs are fed much less corn than in this country, and other feeds such as barley, skim milk, and potatoes form the basis of the hog ration. Partly because of the use of corn as the principal hog feed, the methods of hog production and the type of hog produced in the United States are quite different from those in most other countries.

The location of corn and hog production in the United States has shifted gradually westward during the last 50 years as the Middle West was developed and settled. In 1840 the center of hog production in the United States was in northeastern Kentucky. By 1870 this center was in southern Indiana, by 1900 in west central Illinois, and in 1930 it was in northeastern Missouri. Thus, the center of hog production

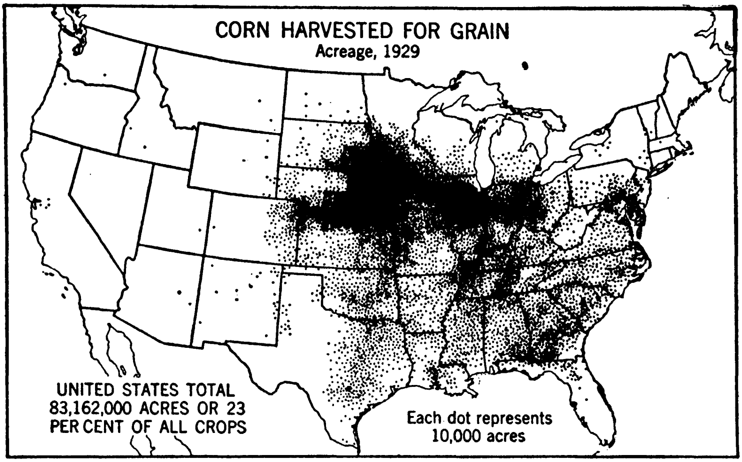


FIG. 104.—Corn acreage harvested for grain is concentrated in a narrow belt, from Ohio to Nebraska.

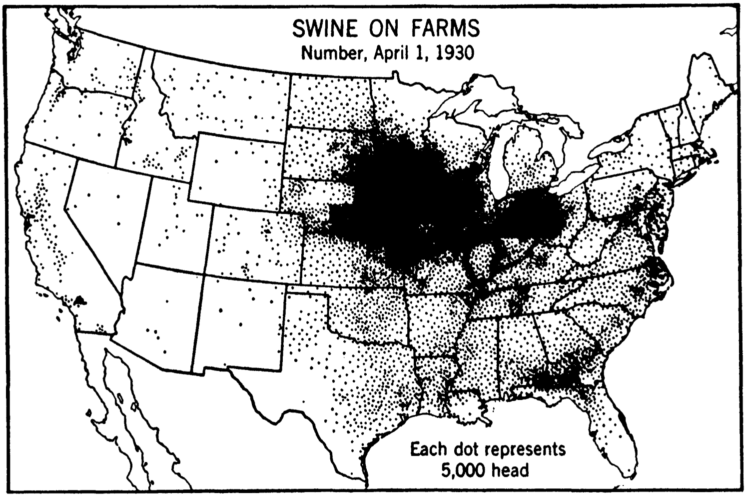


FIG. 105.—Production of hogs is concentrated in the area of heaviest corn production.

in the last century has followed a northwesterly path between 500 and 600 miles in length. Since 1910, as shown in Fig. 106, there has been a marked expansion in numbers of hogs in the western Corn Belt states, notably in Iowa, eastern Nebraska, eastern South Dakota, and southern Minnesota. The increase in corn production in this area was very marked from about 1908 to 1930, and it was followed by a sharp increase in hog production. Between 1908 and 1932 corn acreage in the five

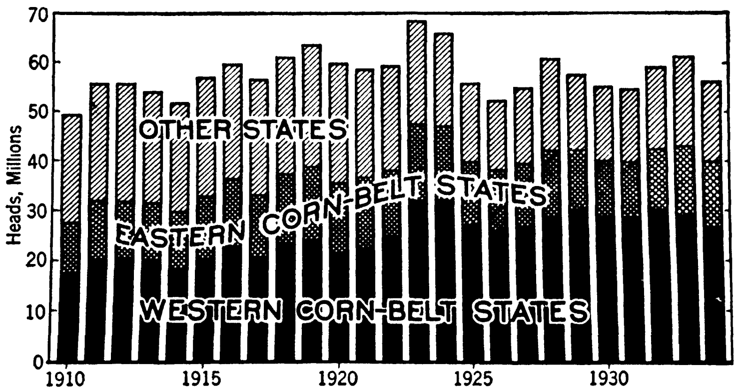


FIG. 106.—Between 1910 and 1930 a marked expansion in hog production occurred in the western Corn Belt States.

northwestern Corn Belt states, Iowa, Minnesota, Nebraska, South Dakota, and North Dakota, increased more than 60 per cent from 20,640,000 acres to 34,000,000 acres. Since the total corn acreage in the United States remained relatively stable during this period the proportion of the total acreage in the northwestern Corn Belt increased greatly. Hog numbers in this area increased about 74 per cent from 1915 to 1929. In the last 10 years on the average of about 30 per cent of the total hog population of the country was located in the northwestern Corn Belt, while in the period from 1900 to 1914 only 25 per cent of the total number of hogs were located in that

region. Since hog numbers on January 1 in the Corn Belt are smaller relative to annual slaughter than in other sections of the country, the increase in the proportion of the output of hogs produced in the Corn Belt has been even greater than the above figures indicate.

Because of the importance of corn as a hog feed, the changes in the relationship between hog prices and corn prices are responsible for a large part of the year-to-year changes in hog production. The usual way of expressing this price relationship is by means of the ratio of the price of hogs to the price of corn. In other words, the price of hogs per 100 pounds is divided by the price of corn per bushel. This ratio frequently is termed, and correctly so, the number of bushels of corn that 100 pounds of hog will buy. Since farmers generally know the quantity of corn normally required to fatten a hog to average market weight, it is natural that they should make some comparison of the value of this quantity of corn and the value of hogs in making their production plans. Thus, in studying changes in hog production the hog-corn price ratio is an important factor.

The changes in the hog-corn price ratio and the changes in hog marketings over a long period of years are shown in Fig. 107. In the upper section of this figure the ratio is shown with the periods when this ratio was below a long-time average indicated by the shaded part of the figure. In the lower section of the chart, hog marketings or hog slaughter are shown. It will be observed from the slanting arrows which extend from the upper section to the lower section that, when the ratio is below average, hog marketings tend to decrease from one to two years later. When the ratio is above average, such marketings tend to increase one or two years after the ratio becomes favorable. Because of the tendency for the effects upon hog marketings of this hog-corn price ratio to be repeated in a similar manner year after year, the idea that hog production and prices move in cycles was developed. These cycles in

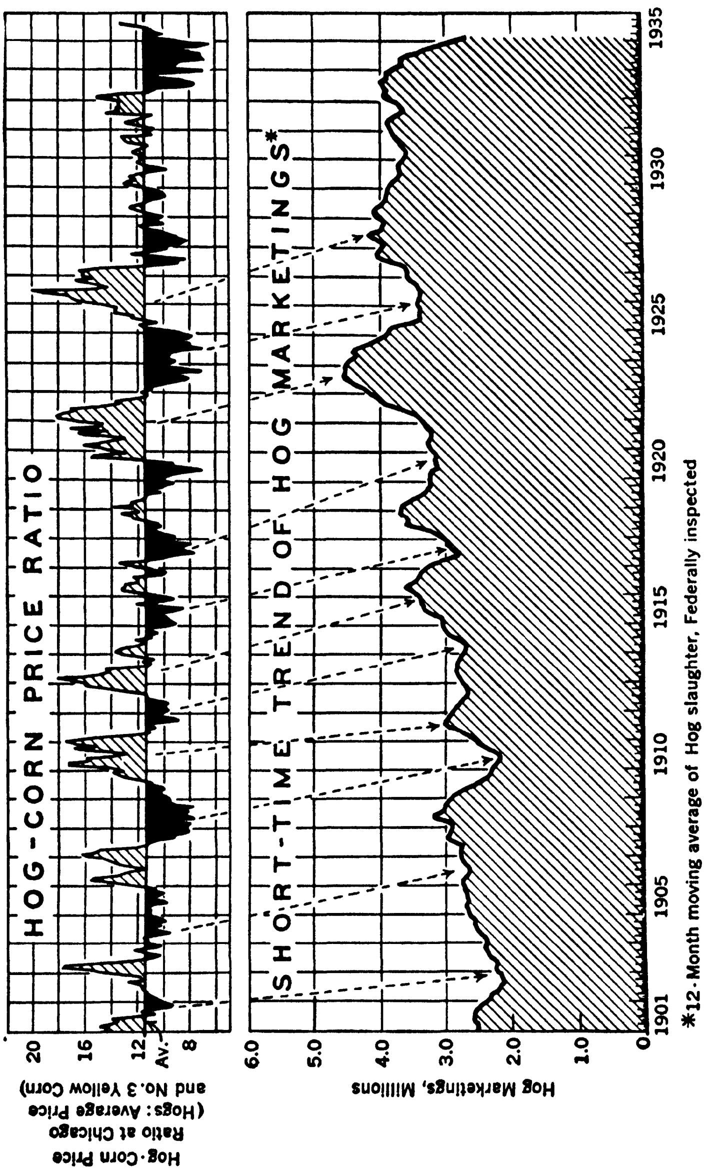


FIG. 107.—Changes in hog production and marketings follow similar changes in the price of hogs relative to the price of corn.

hog marketings are to be noted in the lower section of the chart, which shows that marketings tend to decline from one to two years and then tend to increase for a similar period. This cyclical tendency is also evident in the hog-corn price ratio as is indicated in the upper section of Fig. 107, which shows that the ratio tends to be favorable for one or two years and then unfavorable for a period of similar length. The period of below average hog-corn ratios tends to correspond with the period of large hog marketings, and likewise the period of high ratios tends to be associated with the period of small hog marketings. Thus a complete cycle of hog production, that is, from one period of low production to another, is usually three to four years in length, though some cycles are as long as five years.

It also appears that hog prices themselves tend to move in cycles of about the same length as the cycle of hog production. This cyclical tendency in hog prices is shown in Fig. 108, which gives monthly hog prices over a period of years since 1860 exclusive of price changes due to the fluctuation in the general level of prices. By comparison of Fig. 108 with Fig. 107 it will be observed that the periods of high prices tend to correspond with the periods of small marketings of hogs, while the periods of low hog prices occur at about the same time as the periods of large hog marketings.

This relationship of hog marketings, the hog-corn price ratio, and hog prices is a very complicated one, and it develops because of the interdependence of corn and hogs. In periods when hog marketings are small hog prices tend to be high, and because of the small numbers of hogs on hand the demand for corn is somewhat restricted. Thus the low level of hog marketings tends to raise hog prices and to some extent to lower corn prices. Consequently, the hog-corn price ratio is usually high when hog marketings are small. With the hog-corn price ratio fairly high and continuing so over a period of six months or a year, hog production (number of pigs produced) is stimulated, that is, on the basis of prevailing price relationships it

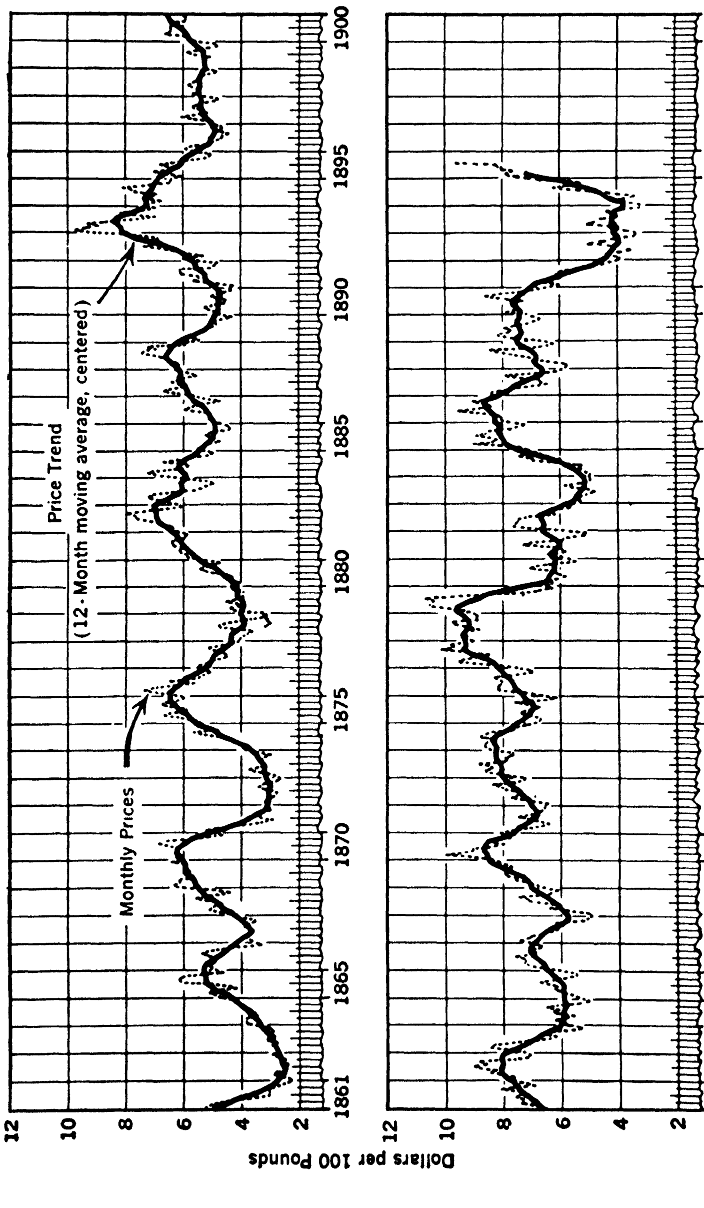


FIG. 108.—Hog prices tend to move in cycles similar to those in hog production.

appears profitable for farmers to expand hog production. Because of the time involved in increasing production and because some farmers react slowly to favorable price relationships, hog marketings are increased and become relatively large from one to two years after the hog-corn price ratio becomes fairly high. When hog marketings increase, hog prices tend to decline, and the increased number of hogs on farms increases the demand for corn so that corn prices tend to rise. Both these factors tend to reduce the hog-corn price ratio. It then becomes more profitable for farmers to sell corn for cash or to feed it to some other class of livestock than to feed it to hogs. Hence, the chain of events with respect to hog marketings, hog prices, and the hog-corn price ratio is repeated.

The foregoing description is a very general one, and in no one cycle do all the events as described above occur. Nevertheless, the tendency exists for these factors to operate. The description given above also assumes a fairly stable level of corn production, which assumption is not always valid. In some years, such as in 1934, a decrease in hog production has been brought about by a short corn crop and high corn prices. In this case the rise in corn prices was the predominating factor in causing the hog-corn price ratio to become unfavorable. With a decrease in hog production and hog slaughter resulting from such a situation, however, and corn production returning to normal in the following years, the factors above described again become operative. It is because of the effects of outside influences, such as droughts, causing a short corn crop, or a decrease in foreign demand, causing a decline in hog prices, that the hog production and price cycles do not occur with precise regularity. Some of the price cycles tend to rise more than others and decline over a longer period. The combination of variations in the feed supply and in the domestic and foreign demand condition has produced a long series of these large and small, or major and minor, hog price cycles. As shown in Fig. 108, a major cycle followed a minor one alternately during the entire period from 1880 to 1930.

Changes in the hog-corn price ratio have one other effect upon hog production. When the ratio becomes favorable or when it is above average, hog producers tend to feed more corn per hog and thus to increase average weights. This increase in weights occurs almost immediately after the ratio becomes fairly favorable, while the increase in the number of pigs produced and slaughtered occurs sometime after the ratio becomes favorable. Conversely, when the ratio declines and reaches a level below average, the quantity of corn fed per hog is curtailed and average weights of hogs marketed are reduced. The effect of changes in the hog-corn price ratio upon the average weight of hogs marketed, however, apparently prevails only within a certain fairly definite range of weights. In other words, if the hog-corn price ratio is relatively favorable, the average weight of hogs slaughtered may increase in any year to as much as 235 or 240 pounds. On the other hand, if this ratio becomes unfavorable, average weights will be reduced to 225 pounds or perhaps 220 pounds in any one year. There are at least two reasons why the effects of the hog-corn price ratio upon average weights of hogs are limited. In the first place, both light- and heavy-weight hogs usually sell at some discount under medium-weight hogs. Secondly, in feeding hogs to extremely heavy weights, much more corn is required per unit of gain after a certain weight is reached.

Factors Affecting Hog Prices

A common statement with respect to prices of hogs and the prices of other commodities is that such prices are determined by supply and demand. Such a statement, however, is of little value to persons interested in hog prices unless it is accompanied by some discussion of the characteristics of supply and demand conditions for hogs. At the outset it should be recognized that the physical operation of the hog industry is from the producer to the packer and thence to the retailer and con-

sumer, but the price-determining movement is the reverse—from the retail market to the wholesale market and from the latter to the packing plant and into the livestock market to the animal.

The supply of hogs marketed during a given year always represents the approximate supply produced and not the quantity of hog products that can be moved at a particular price. The perishability of hogs and hog products, together with the speculative risks involved in storage operations, make only limited holding possible. The hog crop produced in a given year must be marketed usually within a period of twelve months, and the stocks of hog products accumulated in a particular storage season must also be moved into consumption before the next storage season begins. In these respects hogs are different from other agricultural products of a non-perishable nature, such as wheat and cotton.

The immediate demand for hogs is found in the hog markets where the buyers and sellers meet. This demand is for a raw material to be processed, the various products going by different stages to actual consumers. The ultimate demand for hogs then is the demand of consumers for the products of hog slaughter. The actual meeting places of this consumer demand and the supply, which is chiefly pork and lard, is at the retail counter or at the hotel and restaurant table. The effective or organized meeting places are in the wholesale meat and provision markets of all kinds where sales are made to retailers and to buyers for many hotels and restaurants.

It is important to recognize that the producer of hogs sells a raw product which is not in the form to be readily utilized by consumers. Because of the nature of the product, the price which the producer receives for hogs depends upon the price which the consumers pay for hog products and upon the costs of processing and distribution involved in converting the live hog into meat and lard. In studying the fluctuations in hog prices, therefore, it is necessary to study the changes in retail

price of hog products and the variations in the spread or margin between the price of hogs and the retail price of hog products.

In general it may be stated that the retail price of hog products is determined by the quantity of such products available for consumption and upon the incomes or the buying power of consumers. The close relation between changes in the total retail value of hog products consumed in the United States and changes in national income in this country is shown in Fig. 109.

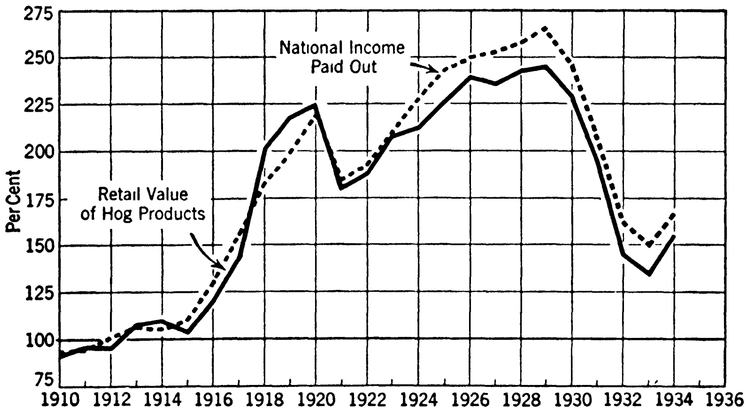


FIG. 109.—Retail expenditures for pork vary with the size of the national income and consumer purchasing power.

It is apparent from this figure that the changes in the total retail value are determined primarily by the changes in incomes of consumers. If the total amount of money spent for hog products by consumers is determined by the level of their incomes, it follows that the price per pound which they pay will be determined by the quantity of such products available and their income, since the total value is the quantity multiplied by the price per pound. Studies of the spread between the price of hogs and the retail price of hog products indicate that processing and distributing costs for hogs and hog products are rela-

tively stable from year to year. Thus it appears that the level of hog prices in any month or year is determined chiefly by the price which consumers in this country and in other countries pay for United States hog products. Since the supply produced in any year corresponds very closely with the domestic and foreign consumption of United States hog products, the two most important factors affecting hog prices are the changes in incomes of consumers in this country and changes in the supply of hogs produced.

Were production to be maintained unchanged from year to year, hog-product prices and therefore hog prices would fluctuate with the total income of consumers, but a given change in consumer income does not mean an equal change in hog prices. In recent years farmers have received about half of the consumer's dollar spent for pork. Consequently a 10 per cent rise or fall in the price paid by consumers, if all passed back to the producer, means a 20 per cent rise or fall in the price of hogs.

National Income and Pork Consumption

The relation of national income and pork consumption can be given very simply in two brief tabulations. One shows the retail prices of pork in the United States that have been associated with the annual consumption from 1920 to 1933 on the assumption that the national income had remained unchanged, and the second shows the effect of changes in the national income on pork prices on the assumption that pork consumption had remained unchanged.

U. S. Pork Consumption, *billion pounds*	U. S. Retail Pork Prices, *cents per pound*
6.5	30 0
7 0	27.2
7.5	24.7
8.0	22.5
8.5	20.8
9.0	19.7

From this tabulation it will be seen that the total retail value of any quantity of pork tends to be about the same; thus 7,000,000,000 pounds at 27.2 cents per pound is about $190,000,000 and 9,000,000,000 pounds at 19.7 cents per pound has practically the same value, $187,000,000.

The relation of national income to retail pork prices is as follows: The prices are straight additions to or subtractions from the prices shown in the preceding table for any quantity of consumption:

National Income, *billion dollars*	Retail Price, *cents per pound* (Addition or subtraction from preceding table)
46	−2 5
52	0
58	+2.5
64	+5 0
70	+7.5
76	+10.0
82	+12.5

This series of national income is such that it amounted to $80,000,000,000 in 1929 and $46,000,000,000 in 1933. In 1935 it amounted to about $55,500,000,000. It represents estimated annual values of goods and services produced.

We may take the 1927 supply and income situation to illustrate the use of the formula contained in these two tables. The volume of pork consumed in 1927 was about 8,100,000,000 pounds. This, according to the relation of consumption to retail prices, indicates a price of about 22 cents. The national income in 1927 was $76,000,000,000. This, according to the relation of national income to pork prices, calls for an addition of 10 cents to the price indicated by the volume consumed. These two prices 22 cents plus 10 cents indicate that the 1927 retail price of pork should have been around 32 cents; the actual price was 32.03 cents.

Figure 110 shows the tendency for hog prices to be high when supplies are small and to be low when supplies are large. This is indicated by the relatively low price in years of large supplies of hogs such as 1922-1923 and 1923-1924. In 1925-1926, however, when supplies were sharply reduced, prices averaged considerably higher than in the three preceding years. In the period from 1922 to 1927 there were no marked changes

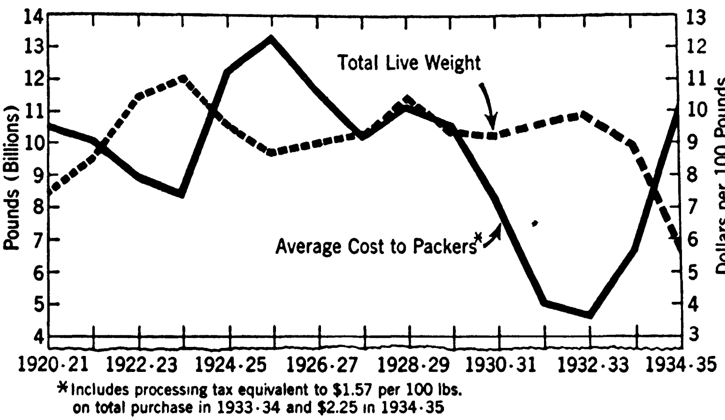


FIG. 110.—Between 1920 and 1927 variations in the total weight of hogs slaughtered were the most important causes of changes in hog prices. In 1930-33 changes in the general price level and in business conditions were more important price factors than supply.

in the demand for hog products, and the variations of hog prices in this period were largely the result of changes in supplies. From 1929-1930 to 1932-1933 there was little change in slaughter supplies of hogs, but hog prices during this period declined to the lowest level in about 50 years. Hence, in this later period changes in domestic and foreign demand and in the general price level were primarily responsible for the variations in hog prices. It is obvious from this figure that changes both in supply and in demand are important in causing changes in hog prices. At some times, however, when demand conditions are

fairly stable, it appears that changes in supplies are the chief factor affecting hog prices, but at other times, when supplies are fairly stable, it appears that changes in demand are the chief factor.

Seasonal Variations in Hog Prices

Chiefly because of the seasonal changes in supplies of hogs for slaughter, hog prices are usually higher in the late spring and the late summer than at other times and are usually lowest for the year in December and January. Slaughter supplies of hogs, on the other hand, usually are largest in the winter months and smallest in the late summer, August and September.

The seasonal character of hog marketings results chiefly from the fact that the farrowing seasons for pigs are of relatively short duration. More than 60 per cent of the pigs produced in the United States are farrowed in the spring, April and May being the months when farrowings are the largest. Fall pigs are farrowed largely in September and October.

Although the length of the feeding period for hogs varies somewhat among different producers and regions, there is a pronounced tendency for a large number of hogs to be ready for market in one or two brief periods during the year. The bulk of the spring pigs is marketed in the period from November to January, and fall pigs are marketed in largest numbers from May to July. The marketing season for the spring pig crop usually begins in late September or early October and extends through late April or early May. Fall pigs are marketed from May to September. In addition to the marketings of fall pigs in the summer season, usually a large number of sows is marketed in the latter part of the summer. Practically all the sows coming to market in the summer have farrowed pigs in the previous spring and to a considerable extent they are marketed from areas where the number of fall pigs produced is relatively small compared with the total pig crop.

Since late September or early October usually is the period

when the marketing of fall pigs is largely completed and the marketing of spring pigs usually begins, October 1 is commonly considered to be the beginning of the hog marketing year. Generally speaking, the marketings of hogs in any year beginning with October represent the pigs farrowed in the spring of that year and fall of the preceding year. Since the spring pig crop is much larger than the fall pig crop, marketings of hogs in the seven months, October to April, usually make up about 65 per cent of the total number of hogs marketed in any marketing year.

As marketings from the spring pig crop increase from October through January, prices usually tend to decline. Following this period in which the bulk of the spring pigs has been marketed there occurs a considerable decrease in market supplies of hogs, and prices usually advance in late February and March with some tendency to decline in April. As marketings from the fall pig crop begin in fairly large volume in May, hog prices normally decline through most of that month and in June. In July, August, and September, when the marketings from the fall crop are reduced and slaughter supplies reach the lowest point of the year, prices usually advance and continue relatively high until some time in October when the new crop of spring pigs begins to be marketed. The normal month-to-month variations in hog prices and slaughter supplies of hogs are shown in Fig. 111. The data on prices and supplies on which this chart was based are for the period 1921 to 1933.

The normal variations in prices of hogs within any one year are usually relatively less than the variations in the supplies of hogs in the same period. This situation results from the fact that in the winter, when slaughter supplies of hogs are large, packers accumulate storage holdings of hog products, and the quantity of hog products entering domestic consumption and export channels at this time is smaller than the volume of such products produced in that season. In the summer, when hog slaughter is much smaller than in the winter, the hog products

accumulated in storage during the previous winter are moved into consumption channels. During the summer the quantity of hog products consumed and exported each month is greater than the monthly production of products. The holding of hog products from winter to summer probably prevents fluctuations in hog prices from month to month from being as great as they might otherwise be as a result of the seasonal changes in supplies of hogs.

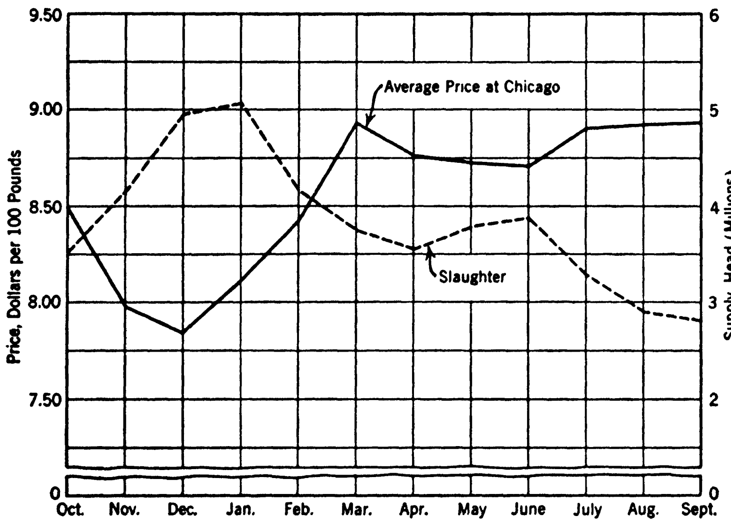


FIG. 111.—Normally hog slaughter is larger in December and January and prices are correspondingly lower than in any other month of the year.

The usual variations in prices and supplies of hogs, as above described, frequently do not correspond with the actual changes in hog prices and hog supplies from month to month. In some years when demand conditions are changing rapidly, as in 1931, the effect of changes in demand upon prices overshadows the effect of seasonal changes in supplies. Also when the level of hog production is changing rapidly the monthly variations in slaughter supplies are often abnormal. Thus, if the fall pig

crop shows a large increase over that of the preceding year after the spring crop has shown little or no change, summer slaughter supplies the following year will represent a larger than usual proportion of the total yearly slaughter. Also, if the increase in hog production begins with the spring crop and if there has been little change in the preceding fall crop, the increase in supplies during the winter months compared with those of the previous summer will be relatively large. Similarly, when production is declining rapidly, abnormal changes in slaughter supplies of hogs from month to month may occur. Thus the seasonal pattern of hog prices in any year may be affected by several factors which are not seasonal in character.

Relation of Exports to the Hog Situation

Since hogs became commercially important in this country substantial quantities of hog products have been exported. The importance of exports to the hog industry is indicated by the fact that in the post-war years (1921-1934) on the average about 30 per cent of the lard and about 5 per cent of the pork produced in the United States have been exported. Before the War, annual exports of hog products in terms of live hogs were about 6,000,000 head. They went as high as 17,000,000 head in 1919 and 12,000,000 in 1923, and as low as 2,000,000 in 1934. The total annual slaughter of hogs in this country in recent years prior to 1935 usually was about 70,000,000 head, and the annual slaughter under federal inspection in the same years usually was about 45,000,000 head.

It will be noted (Fig. 112) that during the period beginning with the end of the Civil War and ending about 1900 the trend of exports in hog products was gradually upward. As European countries became industrialized in the last half of the nineteenth century a strong demand for cheap food products developed in foreign countries. At the same time the western expansion of agriculture and the opening of new lands in this country along with the development of new methods of transportation

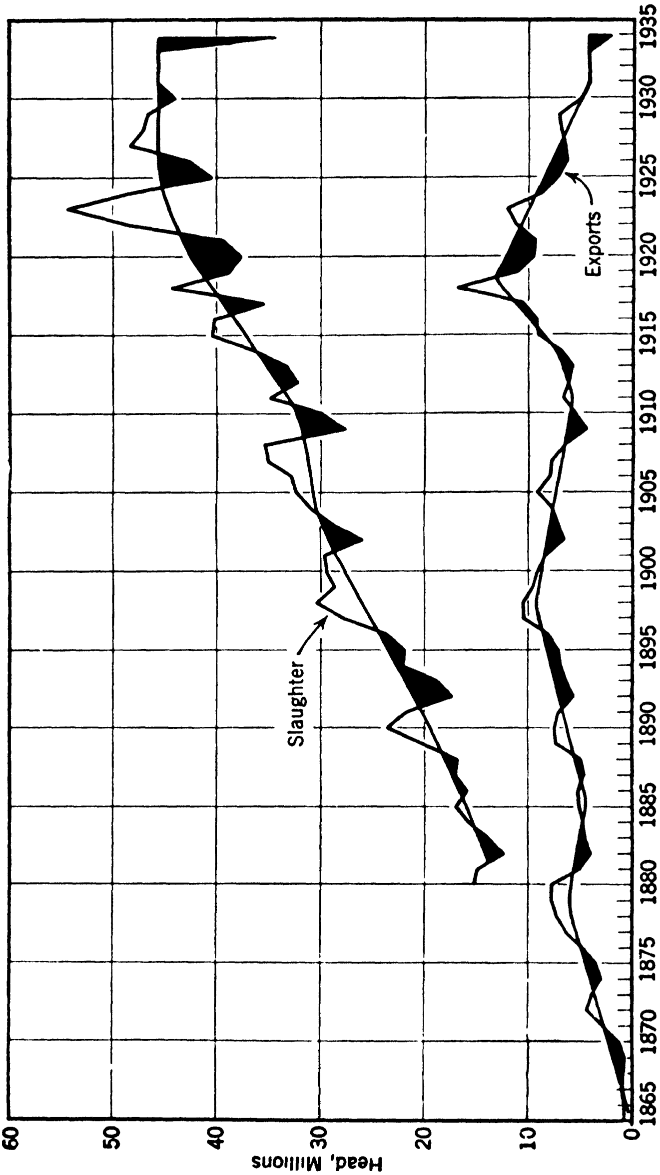


FIG. 112.—Exports of hogs are partly affected by the volume slaughtered. Export peaks occurred in 1880, 1899 and 1918. The decline after the World War reduced exports to less than that of any year since the 1870's.

led to a marked increase in hog production in the United States. Consequently, the increase in exports of hog products from 1865 to 1900 was a natural outgrowth of demand conditions in Europe and supply conditions in the United States.

After 1900 and until the beginning of the World War exports of hog products tended to decline. Among the reasons for this decline in exports were the stabilization of the industrial population in Europe, the expansion in agriculture in Europe prompted partly by restrictions to imports, and the increase in urban population and industrial production in the United States which broadened the domestic outlet for hog products.

The downward trend of exports in hog products was interrupted by the World War, and exports increased greatly as a result of the abnormal war-time demand from Europe for hog products from the United States. Exports of pork increased to the highest level on record in 1919. After the War, exports of hog products decreased as European agriculture was restored to a more normal basis. Thus, the downward trend in evidence from 1900 to 1914 was resumed after the interruption.

The trends in exports of pork and lard have been somewhat different in the last 35 years, as is shown in Fig. 113. From 1900 to 1914 the downward trend of exports was much more significant for pork than for lard. In the War years, however, exports of pork increased much more rapidly and to a much greater extent than exports of lard. This failure of lard exports to increase as much as pork exports was due in part to the fact that exports of lard to Germany, long a leading foreign outlet for lard but not for pork, practically ceased during the War. After the War, when the German market was reopened, exports of lard increased, reaching the highest level on record in 1923. From 1923 to 1934 lard exports did not decline so rapidly as pork exports, and throughout the post-war period exports of lard exceeded those of pork.

The most important factor responsible for the decline in exports in the years from 1920 to 1932 was the marked increase in

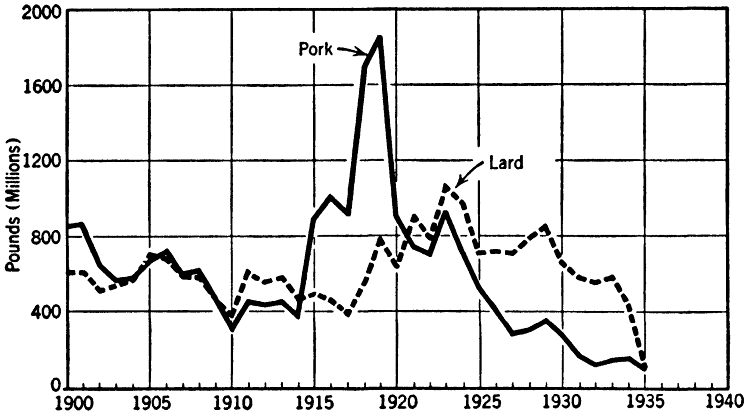


FIG. 113.—The peak in pork exports occurred in 1918-1919 and the peak in lard exports in 1923. Pork exports declined to low levels in 1932, while lard exports suffered less. The reduction in lard exports in 1935 was chiefly due to the 1934 drought.

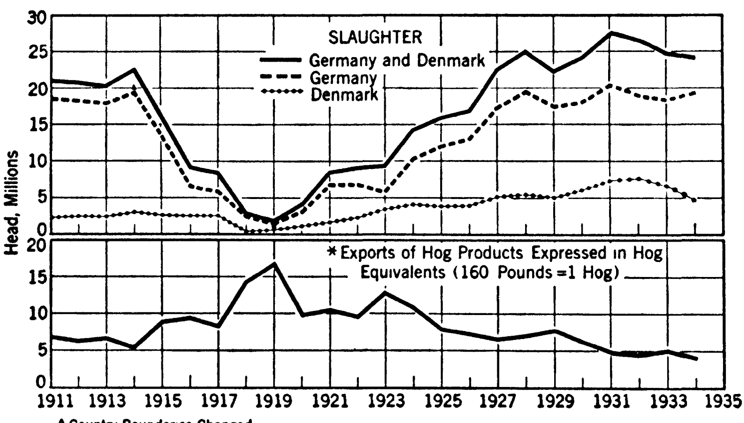


FIG. 114.—The war-time increase in exports of hog products was to fill the demand created by the deficit in Germany and Denmark.

European hog production. The inverse relation between exports of hog products from the United States and hog slaughter in Germany and Denmark is clearly indicated in Fig. 114.

Since Denmark is an important source of cured pork imports into Great Britain, the increase in Danish hog slaughter resulted in larger exports of Danish bacon to the British market and smaller exports of pork from the United States. The increase of hog slaughter in Germany reduced the dependence of that country upon foreign markets for lard, and thus lard exports from the United States were decreased. In the past three years, hog production tended to increase not only in Germany and Denmark, but also in Poland, Holland, Lithuania, and Hungary.

In order to aid their own hog producers, and for other reasons, several foreign countries have placed a rather severe restriction on imports of hog products during the last five years. The most important of such restrictions affecting United States exports were those imposed by Great Britain and Germany. In late 1932 the British government adopted a policy of restricting imports of cured pork from countries outside the British empire by means of a quota system. That is to say, the proportionate share of the total imports from each country was determined, and the total volume of imports to which the proportions apply are changed from time to time, depending upon the market situation in Great Britain. The avowed purpose of the British program has been to aid British pig producers. Total imports from non-Empire countries have been reduced between 30 and 40 per cent since the quota system became effective. Hog prices in Great Britain have advanced and hog production in that country has been increased.

In Germany during 1933 the import duty on lard was raised from about $1 per 100 pounds to about $17 per 100 pounds. The result was a considerable decrease in exports of lard to Germany in 1933-1934. In 1935 the German import duty on lard was reduced considerably, but, because of the policy of the German government with respect to balancing imports from any country with exports to that country, very little American lard was shipped to Germany after the duty was lowered.

Exports of hog products were further reduced from 1934 to 1935 primarily because of the marked decrease in the volume of hog products produced in the United States. It will be observed in Fig. 112 that part of the changes in exports from year to year apparently are brought about by changes in the commercial slaughter of hogs in this country. Thus, when hog slaughter increases materially there is usually some increase in exports, and, conversely, when slaughter is reduced, exports tend to decrease. As already indicated, however, the long-time trends in exports of pork and lard from the United States since 1900 have been associated with factors other than changes in domestic hog production.

The Corn and Hog Surplus

The wartime expansion in corn and hog production and the subsequent falling off in foreign demand helped to create the corn-hog surplus problem of the 1920's and early 1930's. After reaching a relatively high level in 1926, hog prices trended downward until 1934. Although a large part of the decline in prices after 1930 was the result of the prolonged and severe business depression, it should be recognized that during most of the post-war period the price of hogs was considerably lower in relation to the pre-war level than were prices paid by farmers for commodities used in living and production. This relationship between hog prices and prices paid by farmers is shown in Fig. 115. The discrepancy between hog prices and prices paid by farmers became even more pronounced in the depression years of 1930-1933. Among the conditions responsible for the fact that hog prices during most of the post-war period were low relative to prices of products bought by farmers, as compared with pre-war years, were the increased quantity of hog products which had to be absorbed in the home market as a result of the decline in exports of pork and lard, and the somewhat larger hog production in the post-war period than in the pre-war period. Since hogs and hog products are perishable

there were no large accumulated stocks resulting from the decline in exports as there were of wheat and cotton.

In order to measure the surplus of corn and hogs, therefore, consideration must be given to the changes in amounts of corn and hogs available for utilization in this country. In addition to the decline in exports of hog products, exports of corn and other feed grains also declined, and the decline in the number of horses and mules released a large quantity of corn for hog

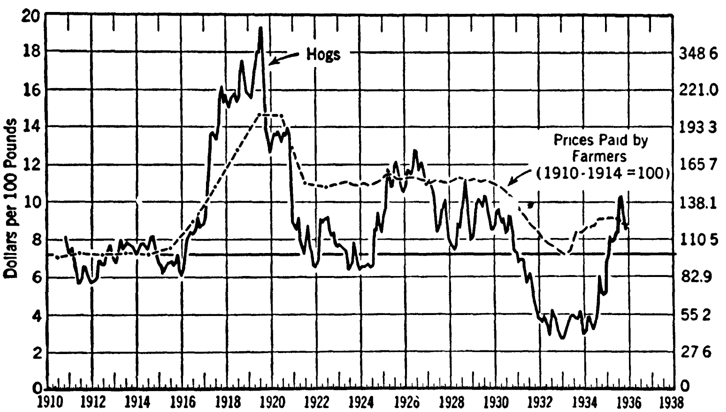


FIG. 115.—Hog prices after the War were relatively lower than prices paid by farmers for industrial goods, except for brief periods in 1925, 1926 and 1935.

feeding. Both of these last-named factors tended to increase hog production, while the first factor increased the quantity of hog products for domestic consumption. The various changes mentioned can be measured only roughly, but each has had some effect upon the corn and hog situation.

During the decade from 1923-1924 to 1933-1934 the decline in exports of hog products was roughly equivalent to about 8,000,000 hogs. The corn required to produce this number of hogs to market weight probably would be about 150,000,000 bushels. In addition to the decline in exports of hog products,

corn exports themselves decreased about 20,000,000 bushels during this same period, making a total direct and indirect decline in exports of corn of about 170,000,000 bushels. On the basis of the ten-year average yield of corn for the entire country about 6,500,000 acres would be required to produce the quantity of corn represented by the decline in exports.

From 1919 to 1933 it was estimated that the decline in the number of horses and mules on farms and in cities amounted to about 10,700,000 head. Data on the utilization of corn by different classes of livestock indicate that on the average about 21.5 bushels of corn per year are consumed per head of horses and mules. The decline in the number of horses and mules from 1919 to 1933, therefore, is equivalent to about 230,000,000 bushels of corn. On the basis of the ten-year average corn yield for the United States, about 8,800,000 acres would be required to produce this quantity of corn. Thus, it appears that the decrease in exports of hog products and of corn and the decline in horse numbers increased the acreage of corn available for other uses, including the production of hogs for domestic consumption, by about 15,000,000 acres, or roughly 15 per cent of the total corn acreage.

The decline in horse numbers also made available for other uses a large quantity of feed grains other than corn. It has been roughly estimated that the decline in horse numbers from 1919 to 1933 was equivalent to about 21,000,000 acres of feed grains, of which 8,800,000 were corn, as already indicated. Since there was a considerable increase in human population in the post-war period, the increased quantity of feed grains available for domestic uses is not so large as the above figures indicate. Such figures, however, do point to a basic change in the corn-hog situation, with lower relative prices for both corn and hogs.

It was to correct the above-described situation that the 1933-1935 corn-hog programs of the Agricultural Adjustment Administration were instituted. That these programs were partially successful is indicated by the substantial reductions in

corn acreage in 1934 and 1935. One of the objectives of the Soil Conservation Program of 1936 that followed the Agricultural Adjustment Administration programs was to continue indirectly the adjustments in corn and hog production which began under the program of the Agricultural Adjustment Administration.

The Hog Price Cycle After 1936

The situation for hogs in early 1936 was such that a marked expansion in production in the next two years seemed probable. The hog-corn price ratio in the first three months of 1936 was higher than it had been at any time in the previous two years. The level of hog prices during the first part of 1936 was higher than in any similar period since 1929. Thus average or better than average corn production in 1936 and 1937 would, according to the usual economic sequence, be followed by a considerable increase in hog production from the 1935-1936 low level and a considerable decline in prices.

In 1934, as a result of the severe drought, corn production was reduced to the lowest level in about fifty years and total production of corn was only about one-half as large as the average production in the last ten years. Production of other feed grains and of hay likewise was sharply curtailed by the 1934 drought. One of the results of this marked decrease in feed crop production was a reduction of 40 to 50 per cent in the number of hogs produced. Inspected hog slaughter in the marketing year beginning October, 1934, was the smallest in more than twenty years. Slaughter in 1935-1936 was only slightly larger than in 1934-1935. This decrease in hog slaughter, along with the improvement in consumer demand, resulted in a material advance in hog prices in 1934-1935.

The corn crop in 1935, although below average, was much larger than that of 1934. As the supply of corn was increased, and the number of hogs to be fed decreased, corn prices de-

clined considerably after the 1935 corn crop became available. The decline in corn prices combined with the rise in hog prices brought about the increase in the hog-corn price ratio already mentioned. As a result of the more favorable feeding ratio and the more plentiful supplies of feeds, the 1935 fall pig crop showed a substantial increase over that of 1934. A material increase in the 1936 spring pig crop was also under way.

Such momentum in production as was set in motion by relatively high hog prices of 1935-1936 is usually not counteracted by other developments within a period of two or three years, and therefore hog prices tend to be dominated for two or three years by the upward trend in supply. This fact, that once the hog production cycle has turned upward the price cycle turns downward and continues to tend downward two to three years, is shown in Fig. 116. Five of the major hog price cycles contained in the long record shown in Fig. 108 have been plotted here so as to show more clearly the usual upward and downward courses of major hog price cycles. These five cycles emerged out of the low prices of 1873, 1879, 1890, 1899, and 1923. The rising phase of the cycle that emerged out of the low prices of 1933 is also shown here. In each cycle the monthly average of prices in the year before the advance began is taken as the starting point, 100 per cent. Thus, on the earliest major cycle shown here, that of the period 1873-1878, the peak was reached in about two and a half years in the spring of 1876, with prices then more than twice as high as in 1873, the previous low price year. In about three years, by the end of 1878, hog prices had returned to the low point from which they had started. (The price cycles in this illustration are exclusive of changes in the general price level.)

The price cycle that started upward in 1880 attained its peak in 1882, in somewhat more than two and a half years, and returned nearly to its previous low point in about three years of decline. The price cycle that started upward in 1891 attained its peak in about two years and the subsequent low point

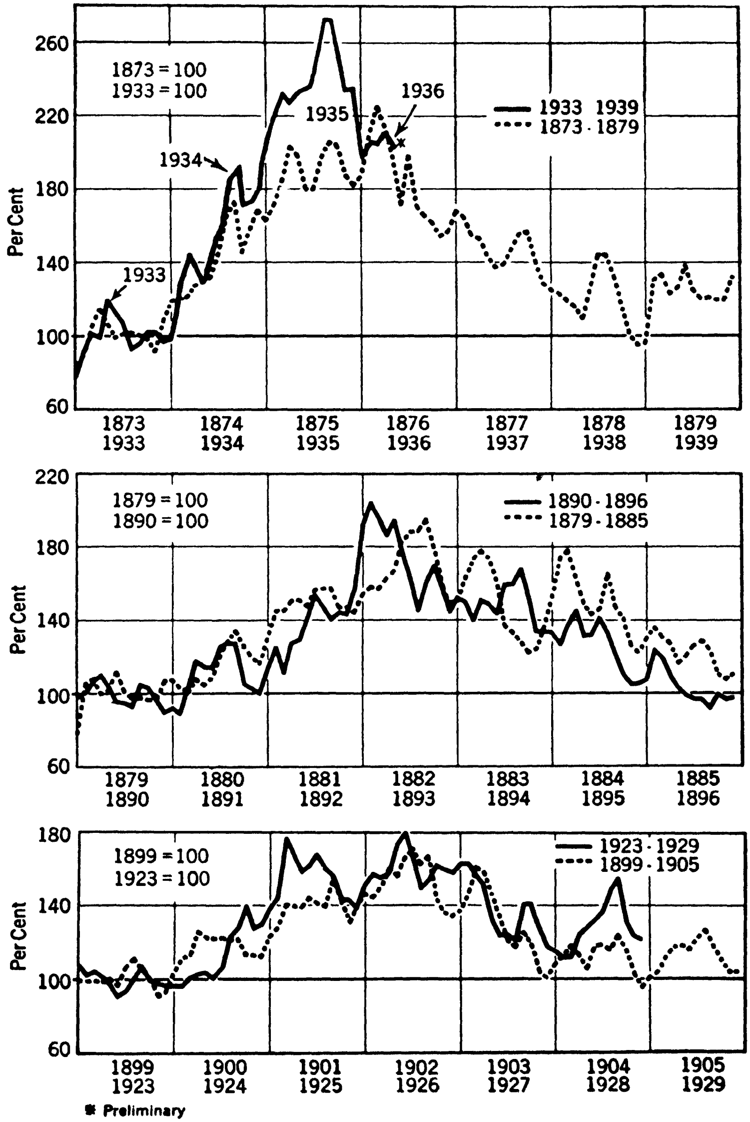


FIG. 116.—The sharpest advances in hog prices occurred after the short corn crops of 1873 and 1874 and 1933 and 1934.

in about three and a half years of decline. The price cycles of 1899-1904 and 1923-1928, though not so pronounced as the others, reveal approximately the same time intervals for both the rising and declining phases.

The changes in supply during each of these periods of rising and falling hog prices were chiefly responsible for the price variations, but they were not of equal magnitude. The most pronounced of the five complete cycles in which prices more than doubled in two and a half years was that of 1873-1878, which had its foundation in the two successive small corn crops of 1873 and 1874. Similarly the cycle price rise of 1934 and 1935 also developed out of a small crop in 1933 and the much smaller crop of 1934, and because the 1934 drought reduced the 1934 corn crop more than the 1874 crop was reduced, hog prices in 1935 rose to more than two and a half times those of 1933 (and attained the peak in a little less than two years. During the first half of 1936 prices were already considerably below the peak reached in 1935 but were still about twice the prices of 1935 (after allowing for the higher general price level).

This illustration should be useful in observing to what extent the downward phase of the price cycle starting from the 1935 peak repeats the characteristics of the previous cycles. The last point shown for 1936 represents a price of $9.00 and a commodity price level of 80 (the 1926 price level taken as 100). Given an unchanged price level during 1936-1938, which implies fairly stable domestic demand conditions, and an unchecked expansion in hog production, without our former foreign outlets for lard and pork, hog prices by the end of 1938 could, according to previous experience, be expected to go to about half of what they were during the first part of 1936. But the small corn crop of 1936, which came in the second season after the small crop of 1934—a situation quite different from any on record—is certain to delay the downward price trend.

SELECTED LIST OF REFERENCES

WALLACE, H. A. Agricultural Prices. Wallace Publishing Co., Des Moines, Ia. 1920.

HAAS, G. C., and EZEKIEL, M. Factors Affecting the Price of Hogs. U. S. D. A. Dept. Bul. 1440. 1926.

ELLIOTT, F. T. Adjusting Hog Production to Market Demand. Ill. Bull. 293. 1927.

BEAN, L. H. Major and Minor Hog Price Cycles. U. S. D. A. Agricultural Situation. 1928.

VOORHIES, E. C., and BLANK, M. H. Swine. Cal. Bull. 523. 1932.

WELLS, O. V. Farmers Response to Price in Hog Production and Marketing. U. S. D. A. Tech. Bull. 359. 1933.

ANONYMOUS. The Direct Marketing of Hogs. U. S. D. A. Misc. Pub. 222. 1935.

CHAPTER XXIV

CORN AS AFFECTED BY TEMPERATURE AND RAINFALL

CORN requires abundant moisture and a moderately high temperature if it is to make its best growth. Laboratory experiments indicate that, when plenty of moisture is available, a temperature of about 90° is most favorable both for germination and growth. Growth stops altogether at temperatures below 40° or above 118°.

Temperature for germination.—In most corn-growing sections, the temperature during the week following planting is around 60° to 65°, and under such a temperature corn usually appears above ground in eight or ten days. When the ground is cold and the temperature averages 50° to 55°, it usually takes eighteen or twenty days for the corn to come up. When the temperature is less than 55°, the slowly sprouting corn kernels are very susceptible to root rot infections, whereas when the temperature is above 60° the kernels are much more resistant. If the soil is warm and moist and the corn is planted shallow, a temperature of 70° will bring it above ground in five or six days. In the central part of the Corn Belt, yield and temperature records indicate that a mean temperature of 55° or less during May tends to reduce the yield by about 15 per cent. A temperature of 56° to 58° will not ordinarily cut the yield by more than 3 or 4 per cent, unless accompanied by heavy rains and prolonged cloudy weather. The higher the average temperature in May the better the yield of corn in the Corn Belt states east and north of the Missouri River. The opposite relationship holds in Nebraska, Kansas, and Missouri, where above-average temperatures are usually accompanied by dry weather.

Temperature and rainfall during June.—From the time the corn comes up until it reaches a height of 3 feet, it is necessary under practical farm conditions to give three or four cultivations, in order to kill the weeds. This can be accomplished most effectively when June is rather hot and dry. A mean temperature of 70° to 72° in June, with 2 to 4 inches of rain, seems to be ideal. A mean temperature of more than 75° for the month of June is so often accompanied by exceedingly dry weather, not only in June but also in July, that it is a matter of history that years of exceedingly hot Junes are usually years of below-average corn crops. Warmer-than-average June weather is favorable to corn in Ohio and Minnesota, but usually reduces the yield in Missouri, Kansas, Nebraska, and South Dakota. The greater the rainfall in June, the better the yield of corn in Kansas.

July weather and corn yield.—In Ohio, Indiana, Illinois, Missouri, Kansas, Nebraska, and southern Iowa, the rainfall and temperature during the ten days before and the twenty days following tasseling time have more to do with corn yield than the weather at any other period. Ideally, there should be 4 or 5 inches of rainfall during this thirty-day period, and the mean temperature should average from 72° to 74°. Corn appreciates mean temperatures as high as 85°, but as a practical proposition, mean temperatures above 75° nearly always lower the yield for the reason that such temperatures cause the corn plants to transpire water more rapidly than they can take it up from the ground. This might not be true under irrigation, but in the Corn Belt mean temperatures above 75° are usually accompanied by drought. It is also true that a drought which would cause very little bother at 70° may be a serious matter at 80°, for it has been found at the Nebraska station that a full-grown corn plant will transpire daily about 4 pounds of water at a mean temperature of 70°, whereas at 80° it will transpire about 7 pounds.

During this thirty-day period, on land capable of producing

40 bushels per acre under favorable conditions, each degree that the mean temperature averages above 74° cuts the corn yield by about 1.2 bushels per acre, and each inch the rainfall is below 4 inches cuts the yield by 2 bushels. For instance, with land yielding 40 bushels per acre under the best conditions, if the corn starts to tassel on July 18 and the temperature from July 8 to August 7 averages 78° and the rainfall totals 2 inches, the indicated yield would be 40 bushels minus 4.8 bushels because of high temperature and 4 bushels because of drought, or 31.2 bushels.

Ample rainfall is more important in the production of a good corn crop during July than in any other month. This is true in all parts of the Corn Belt. The higher the July temperature, the smaller the yield of corn in all Corn Belt states except Minnesota, where warmer-than-usual July weather, ordinarily, is needed to produce an above-average crop.

A general 1-inch rain during late July often increases the prospective crop of the Corn Belt states by 2 or 3 bushels per acre, or by a total of more than 100,000,000 bushels. Some people have, therefore, spoken of such a rain as worth millions of dollars to the farmers. As a matter of fact, December future corn prices as set by the Chicago Board of Trade during July and early August reflect these rains in such a way as to leave the total prospective value of the new crop changed but little. The rain which increases the prospective corn crop of the Corn Belt by 100,000,000 bushels, or by 7 per cent, will also lower December corn future prices by 6 to 12 per cent. The July and early August rains which add 100,000,000 bushels to the coming crop of the Corn Belt usually result in the new corn being priced 4 or 5 cents a bushel cheaper, or enough to make the total value actually somewhat less than if the rain had not come. It is the corn product manufacturers, exporters, and stockmen who buy more corn than they raise, who benefit by the July and August rains which increase the corn crop. And, of course, it is always true that those corn sections which receive

heavy July rains when the Corn Belt generally is hot and dry, benefit enormously at the expense of their less fortunate neighbors.

December future corn prices and July weather.—Generally speaking, the Chicago December future corn price, as quoted

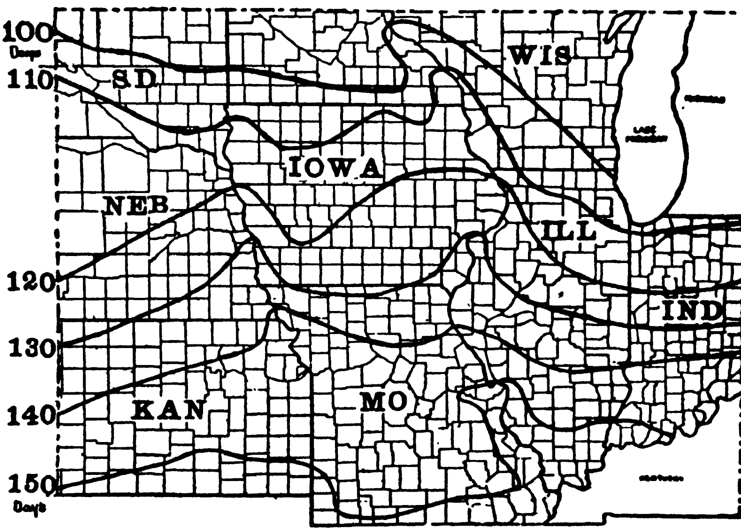


FIG. 117.—Number of days from time temperature normally rises above 61° in spring until it goes below 65° in the fall. This map indicates fairly accurately where the early maturing strains are required. In northeastern Illinois much earlier varieties are required than in the same latitude in Iowa. In northeastern Iowa earlier varieties of corn are required than in northwestern Iowa, even though the former has a longer season. The explanation lies in the soil type and the slowness with which it warms up in the spring.

day by day during July and August in the daily papers, is the best measure for the average farmer of how the new corn crop of the entire Corn Belt is being treated by the weather. If on July 30 the December future price is 6 cents a bushel higher than on July 20, it is an indication that there has been prac-

tically no rain anywhere in the Corn Belt during the past ten days. If the price during this period has dropped by 2 cents a bushel, it is almost certain that there have been abundant, well-distributed rains over the greater part of the Corn Belt. Sometimes December corn futures during July and August are affected to some extent by business conditions and by wheat prices, but as a rule they move up and down in sympathy with Corn Belt weather and very little else.

Northern Iowa and southern Minnesota differ from the central part of the Corn Belt in that they are more likely to be damaged by cold and wet during May and June than by heat and drought during July. It is only in years of exceptional drought, like 1894, 1901, 1934 and 1936, that the northern part of the Corn Belt is likely to suffer much from hot July weather. Even in such years, the corn of the northern Corn Belt is usually not so very far below normal, whereas there is a great shortage in the central and southern parts of the Corn Belt. The net result, as a rule, of dry, hot July weather, so far as Northern corn farmers are concerned, is prosperity at the expense of the corn farmers farther south. On the other hand, cold, wet summers like 1915 and 1917 hurt the corn yields in the North and boost those south of central Iowa.

From a commercial standpoint, drought and heat during July and early August have much more effect on the corn market than cold and wet at any time of the year. In the recent droughts of 1934 and 1936 the greatest changes in corn prices occurred from July 1 to August 20. The great reductions of nearly a billion bushels in each of these years brought sharp increases in prices. See Page 336 for a discussion of weather and prices.

August weather.—Over most of the Corn Belt, heat and drought during the first half of August are almost as likely to hurt the corn crop as heat and drought in July. Missouri, Nebraska, and Kansas corn is especially susceptible to heat damage during the first half of August. North of central

Iowa, however, the corn yield is more likely to be damaged by cold weather in August than by hot weather. August weather averaging below 69° seems to damage the corn crop in northern Iowa and southern Minnesota, especially in years when the May, June, and July weather has also been a little cooler than normal. The ideal August weather is a temperature of 72° to 73° and a rainfall of 4 or 5 inches.

After August 20, the weather usually has very little significance. The corn plant at this time is manufacturing and storing sugar and starch much more rapidly than earlier in the season. Nevertheless, after thirty days have lapsed following tasseling, moderately dry weather seems to do no damage. Rainfall is important while the young corn kernels are just forming but is not so necessary when the corn plant is most actively at work storing food in these kernels during late August.

Frost.—Frost has far less effect on the corn crop than most people think. In a season which has been usually cool throughout, like 1915 or 1917, a September frost may cause much soft corn north of southern Iowa. Occasionally, as happened in 1920 and 1927, unusually warm September weather enables the corn crop to avoid the frost damage which seemed almost inevitable. It is only rarely that frost causes any widespread damage to corn. As a rule, most corn is sufficiently matured to withstand frost damage two or three weeks before killing frost actually comes. Frost damage is rarely reflected in the price of corn on the terminal markets in the same way as heat and drought damage.

Heat and rapidity of growth.—While mean temperatures above 74° during the twenty days following tasseling time seem to harm the corn crop, it is also true that previous to tasseling time the rapidity with which the corn grows depends largely on the temperature. During June and early July, corn grows twice as fast on those days when the mean temperature is 78° as it will when the mean temperature is only 62°. A

75° mean results in about 25 per cent faster growth than 70°. A number of years ago, the Pennsylvania station found that during the three weeks preceding tasseling time there was a tendency for corn to grow in twenty-four hours at the following rates at varying mean temperatures:

65°	3.2 inches
70°	4.1 inches
72°	4.5 inches
75°	5.1 inches
78°	5.4 inches

The average temperature during the fifty or sixty days following planting time is the chief influence determining just when a given variety of corn will tassel. With the ordinary 115-day strain of such varieties as Reid Yellow Dent, the temperatures during the sixty days following planting result in varying lengths of time till tasseling:

68°	71 days from planting to tasseling
70°	67 days from planting to tasseling
73°	59 days from planting to tasseling

With a so-called ninety-day strain, the corresponding table, based on temperatures during the forty-five days following planting time, is:

67°	57 days from planting to tasseling
69°	50 days from planting to tasseling
71°	45 days from planting to tasseling

All three of the tables given here apply most accurately to average Corn Belt soil. On soil of unusual fertility the rate of growth will be somewhat more rapid.

The number of days from tasseling to ripening does not vary with the heat in the same clear-cut fashion as the number of days from planting to tasseling. With most varieties of corn it takes from fifty to sixty days from tasseling to maturity with ordinary temperatures.

Extremely high temperatures (above 95° during the heat of the day) may kill the pollen within an hour or two after it is shed and thus cause poor pollination if the high temperatures are continued day after day at the time the pollen is flying. The storing of food in the corn kernel during late July and August is an altogether different process from the rapid growing of the corn plant during late June and early July. Hot weather does not have as much to do with hastening ripening as it does with causing rapid growth before tasseling.

Cold nights.—It is common belief that corn will not grow satisfactorily in regions where the nights are cool though the days are warm. Usually, the true explanation why corn is not grown in such sections is something else. In South Africa, where corn growing has expanded at a phenomenal rate since 1900, the minimum temperature at night during the tasseling season averages only about 60°, and in some sections it is as low as 55°. Cool nights reduce the rapidity of growth previous to tasseling, but if the season is long there is no definite proof that cool nights (55° to 60° at the low point of the night) reduce the yield.

Summary.—The ideal corn season in the central part of the Corn Belt is about as follows:

May—65° mean temperature (warmer than average), 3.5 inches of rain.

June—71° mean temperature, 3.5 inches of rain.

July—73° mean temperature (cooler than average), 4.5 inches of rain.

August—73° mean temperature, 4.5 inches of rain.

September—Warmer and drier than average, especially if the earlier months have been cool.

October—Same as September. It is usually in cold, backward seasons that September and October have any great significance. Dry weather in October helps the quality of corn and enables it to grade sooner than it would otherwise.

No temperatures above 96° in the heat of the day at tasseling time, ground thoroughly saturated with moisture during the twenty days following tasseling.

SELECTED LIST OF REFERENCES

WALLACE, H. A. Mathematical Inquiry into the Effect of Weather on Corn Yield in the Corn Belt States. U. S. D. A. Mo. Wea. Rev. Vol. 48. No. 8. 1920.

SMITH, J W. Agricultural Meteorology. The Macmillan Co. N. Y. 1920.

REED, C. D. Weather and Corn Maturity in Iowa. U. S. D. A. Mo. Wea. Rev. Vol. 55. No. 11. Pp. 485-8. 1927.

CHILCOTT, E. C. The Relations between Crop Yields and Precipitation in the Great Plains Area. U. S. D. A. Misc. Cir. 81. 1927.

MATTICE, W. A. Weather and Corn Yields. U. S. D. A. Mo. Wea. Rev. Vol. 59. No. 3. Pp. 105-12. 1931.

ROBB, A. D. The Critical Period of Corn in Northeastern Kansas. U. S. D. A. Mo. Wea. Rev. Vol. 62. No. 8. Pp. 286-9. 1934.

CHAPTER XXV

COMMERCIAL PRODUCTS OF CORN

About 220,000,000 bushels, or 8 per cent of the corn crop of the United States, is manufactured annually. Roughly, 100,000,000 bushels, or 4 per cent, are ground in the corn meal mills, and 80,000,000 bushels, or 3 per cent, are handled by the starch factories. About 40,000,000 bushels, or about 1.5 per cent, of the corn crop is used in the manufacture of alcohol, lye hominy and in miscellaneous ways.

Manufacturing Processes for the Major Products

Dry process.—The corn meal mills manufacture the meal by what is known as the dry process. In the early days of corn milling, the entire kernel was ground. This made an excellent quality of corn meal, although some people objected to it because of the fine particles of hull. The greatest objection, however, was the presence of the germ in the meal, which made the meal rancid if kept a great length of time. Modern corn milling, therefore, involves degerminating the corn as its first step. The corn is sprayed with water or treated with steam until it has a moisture content of about 20 per cent, after which it goes into a machine with a rapidly revolving core, which results in breaking up the kernel in such a way as to loosen the hull and the germ but not to grind the starch. By mechanical processes, the hard starch is separated and ground into the commercial corn meal as we know it to-day, or, as some people call it, " hominy grits." If the meal is ground extremely fine, it makes what is known as corn flour, which can be mixed with wheat flour to produce a

product which is just as good as pure wheat flour, although the bread made from it does not rise quite as much.

The soft white starch is mixed with the hulls, which are commercially known as corn bran, to make what is known as hominy feed. Extensive experiments with hominy feed in Iowa and Indiana indicate that it has practically the same value for hogs as shelled corn. The germs are sometimes ground and mixed with the hominy feed; but in the more up-to-date plants the oil is pressed out. The oil cake which is left after pressing out the oil is generally mixed with the hominy feed. Under good conditions, a bushel of corn, under the dry process, produces about 36 pounds of corn meal, 18 pounds of hominy feed, and 2 pounds of oil.

In the manufacture of cornflakes, the dry process is used until the coarse particles of horny starch are separated out. These are rolled out and toasted. Most of the cornflakes are manufactured by three large plants at Battle Creek, Michigan. They use about 10,000,000 bushels of corn annually.

Wet process.—The starch factories do not use quite as much corn as the corn meal mills, but the process is far more complicated, and the products are much more extensively used in a wide variety of industries. The method of manufacture is known as the wet process. A bushel of corn as manufactured in a starch factory by the wet process produces about 34 pounds of starch, 15 pounds of gluten feed, 1.5 pounds of corn oil and 1.5 pounds of corn oil cake meal. Of the 34 pounds of starch which are obtained from the ordinary bushel of corn, only about 12 pounds are usually sold by the starch factories in the form of starch. Most of the rest (about 16 pounds) is usually converted into corn syrup. Sixteen pounds of corn starch make 19 or 20 pounds of corn syrup or glucose. About 8 pounds of the original 34 pounds of starch obtained from a bushel of corn are made into a corn sugar. Both corn syrup and corn sugar are extensively used in candy making, ice cream, preserving, etc. Of the sugar used in commercial candies, over one-third comes from corn. People in the United States who eat candy are

patronizing the farmers of the Corn Belt to almost as great an extent as they are the planters of Cuba and Hawaii. The refined sugar which came into vogue in 1923 can be used very satisfactorily as a substitute for cane sugar except in jellies.

The wet milling process of corn manufacture is briefly as follows:

The corn first goes through a very thorough purification process by which dust, particles of corn cobs, nails and other impurities are removed. The corn is then steeped for about thirty-six hours in lukewarm water to which is added a small amount of sulphurous acid. This is necessary for it prevents fermentation and also softens the corn, allowing a better separation to take place later on in the process. Most of the sulphurous acid is lost in the steps to follow: The steeped corn is fed into disintegrator steel mills, which crush the kernel but do not grind it. In this crushing the elastic germ remains unbroken and is easily separated from the remainder of the kernel. This is done by passing the crushed mass into "germ separator tanks," in which the germs, containing 60 per cent oil, rise to the top and are removed by a mechanical skimming apparatus. They are then thoroughly washed with water in rotating sieves to remove all traces of gluten and starch which may adhere to them.

The lumps of endosperm, hulls and loose particles of gluten and starch leave the separator tanks as tailings. This mass, coming from the bottom of the tanks, goes to the buhr mills, in which it is ground fine. It is then pumped over revolving silk sieves, where the hulls are removed and washed free from adhering gluten and starch, which pass through the fine silk cloth. The hulls, separated in the rotating sieves, are partly dehydrated and then thoroughly dried in steam dryers. They are later mixed with the gluten to form "gluten feed."

The mixture of starch and gluten suspended in water and passing through the sieves during the separation of both the germ and hulls is run off at a regulated speed over long sloping troughs or tables. The starch being the heavier settles down

into a solid cake, while the gluten suspension runs off the tables as tailings. The gluten liquor is collected in cone settlers where it is concentrated. The concentrated liquor is filter pressed and the resulting gluten (containing about 55 per cent protein) is dried and mixed with the hulls to form "gluten feed." To this gluten feed, before it is finally dried, is also added the concentrated steepwater, containing food materials which were dissolved out from the corn.

The somewhat solid cake of starch on the tables is removed by churning it up with a heavy stream of water. The starch liquor is filter pressed and the press cake rapidly dried into so-called "pearl starch," or pulverized and sold as powdered starch. For food purposes the starch is subjected to a number of washings before it is filter pressed, dried and powdered. These starches find their way into the market in bulk or in package form under the various trade names such as "Buffalo," "Kingsford Silver Gloss," "Duryea" or "Argo Gloss." Some of these starches are also made in crystal and in lump form. For laundry purposes there are prepared various grades called "thin boiling starches." Dextrines, used for making adhesives, sizing mixtures, etc., are made from powdered starch.

Dent corn, which is used mostly by the corn products industry, contains practically no sugar of any kind. Corn sugars and syrups are made by changing, by hydrolysis, the starch into the sugar or syrup, as the case may be. The process is briefly as follows: The starch liquor from the tables is first rewashed and then pumped into large vessels capable of being subjected to high pressures. The starch liquor is heated in these convertors with a very small amount of muriatic or hydrochloric acid under a pressure of about thirty-five or forty-five pounds, depending on whether it is desired to change the starch completely into sugar or only partially to form corn syrup. After this treatment the liquor (corn sugar or syrup) is blown into large tanks, in which the muriatic acid is neutralized with soda ash. As a result of the action between the acid and soda ash there is formed a small amount of common,

harmless salt which is found in traces in all corn sugar products. After the neutralization the liquors are passed through a mechanical separation to remove the suspended matter present. To remove color these liquors are run over bone-black filters. They are then partially concentrated in vacuum pans, again decolorized with bone-black and finally concentrated by evaporation to the desired gravity.

The sugar liquor, after concentrating, is run into barrels, where it solidifies on cooling. These grades are used in many industries, among them the brewing, tanning and sugar color making. A higher grade sugar is made by running out the concentrated sugar liquors into large boxes in which it solidifies. When hardened to a certain degree it is cut into small rectangular pieces. These, after proper curing, are wrapped in press cloths and placed in hydraulic presses, where they are subjected to a high pressure. The mother liquor, containing non-crystallizable matter, is forced out. This is called " hydrol " and corresponds to molasses in the cane sugar industry. The sugar cakes are then broken up, dried and pulverized. Corn sugar produced in this way is used in baking, manufacture of chewing gum, candies, etc.

Recently a new method for the production of an extremely pure corn sugar was tried out and found to be successful. In this method the sugar is crystallized out of the sugar liquor under slow motion, and under conditions paralleling those in use for producing white cane sugar. This resulted in a sugar of 99.5 per cent purity, i.e., 99.5 per cent pure dextrose. Previously the highest purity obtained in the finished sugar was 95 per cent. This sugar, " Refined Cerelose," is only about three-fifths as sweet as cane sugar, but carries, pound per pound, fully as much value as cane sugar, and is more digestible and healthful. A slightly more purified sugar has been used recently by physicians for baby feeding experiments. The corn sugar was found to give wonderful results in this connection, and as a result many physicians are prescribing it continuously. " Refined Cerelose " has been found to be satisfactory for use

in confectionery, ice cream, and baking. Its use for condensed or evaporated milk will also prove satisfactory. Only about 5,000,000 bushels of corn were used in the manufacture of corn sugar in 1928.

Corn oil.—The germs, after drying, are conveyed to cylindrical steel mills and ground to a fine powder. This oil meal is heated and passed through presses. The cake from which the oil has been pressed is ground up and sold as oil cake meal. The oil run off from the presses goes through a refining process, in which it is filtered, neutralized, decolorized and clarified, deodorized with steam, chilled and again filtered. This results in the edible corn oil of commerce. It makes an excellent salad oil, which many housewives believe to be fully equal to the more expensive olive oil. It is the most valuable product on a pound basis that is produced from corn.

Corn products companies.—The Corn Products Company is the largest single factor in the wet-process manufacture of corn. Previous to 1907, the wet-process factories were on a weak financial basis. When a large number of the plants were consolidated into the Corn Products Company, under Standard Oil guidance, the situation was not greatly changed for a time. Then the company began selling its starch, syrup, oil, etc., to the public under brand names which were well advertised. The Corn Products Company plants are now located at Argo and Pekin, Illinois; Kansas City, Missouri; and Edgewater, New Jersey. The three independent companies in Iowa are at Cedar Rapids, Clinton, and Keokuk. Some of the independent companies are connected with the Corn Products Company more or less indirectly.

Types of Corn for Wet and Dry Processes

It should be noticed that the corn meal mills and the starch factories are best served by different types of corn. Both appreciate a corn high in oil, but the corn meal mills' chief product is made out of the horny starch, whereas the starch fac-

tories' chief product is made out of the soft starch together with a part of the horny starch. The corn meal mills sell the soft starch and the hulls as an animal feed; the starch factories sell the glutinous part of the hard starch and hulls as animal feed. It would seem, therefore, that a flinty corn rich in protein would serve the corn meal mills best, but a rather soft corn low in protein would serve the starch factories better.

Alcohol from Corn

Corn purchased for the manufacture of alcohol arrives either shelled or on the cob. If on the cob, the corn must be shelled, and the residual cobs constitute a disposal problem. Some attempt has been made to use them as a source of acetic acid by fermentation with special cultures of bacteria. The shelled corn is blown free from dust, crushed, and sifted, the endosperm removed for utilization for producing corn oil and stock food, and the crushed corn is then steeped, heated under pressure to gelatinize the starch, and treated to convert the starch into sugar. This can be accomplished by the use of the enzyme of malt (germinated barley), known as diastase, or by pressure cooking with dilute acids. If acid is used, the subsequent mash must be neutralized before fermentation. The digested or hydrolyzed mash is passed into fermenters where yeast is added after the entire mass has been brought to about 80° F. A vigorous fermentation ensues, which is sometimes aided by the addition of ammonium sulphate or similar salts to stimulate yeast activity. Under existing regulations a legal time limit is placed on the duration of the fermentation, and for this reason, as well as for efficient refinery operation, the various operations must fall within very definite time schedules. The yeast breaks down the sugar into alcohol and carbon dioxide. After the evolution of carbon dioxide has ceased, the fermented wort is pumped to a beer still, which is a vertical column provided with interior baffle plates through which the wort liquid descends, meeting a counter-current of low-pressure steam

which picks up the dilute percentage of alcohol and carries it to the top of the column where a series of refining plates bring the alcoholic concentration up to about 50 per cent. The flow of wort is so regulated that the discharge from the base of the column contains practically no alcohol. This discharge may then be evaporated and processed to make an ingredient of stock feed, or if too dilute it is discharged down the sewer.

To a great extent corn is used for the production of potable alcoholic beverages such as whiskey. The distilling methods in this industry may differ from the methods for producing industrial alcohol. In the latter case the weak alcohol from the top of the beer still is passed to storage tanks for re-refining, or in the continuous-type stills passes directly to the refining column where the alcoholic concentration is brought up to 95 per cent or greater, depending on the use to which the alcohol is to be put or on the refinery method of operation. Ordinarily denatured alcohol as well as beverage alcohol is made from spirits of 95 per cent concentration. For certain purposes, however, an anhydrous grade of spirit is required, to produce which involves operating the refining column to secure the highest possible alcoholic concentration, and the subsequent redistillation of this alcohol with benzene (azeotropic mixtures); anhydrous salts such as calcium sulphate, sodium alcoholate, sodium acetate, or other dehydrating agents; or vacuum distillation, whereby the concentration is brought up to about 99.5 per cent.

The by-products of the operation are: stock feed (which is equal to approximately 22 per cent of the original corn), carbon dioxide (which may be recovered and compressed and sold as dry ice), and "fusel oil." About 600 pounds of solid carbon dioxide is produced per ton of corn. The fusel oil, which is produced in very small amounts, is a mixture of higher alcohols, principally amyl, and some esters (as butyl and amyl acetates, propionates, etc.) and has had certain commercial value

because of its property of dissolving nitrocellulose, for use in lacquers, etc.

The present proposal of employing alcohol as a motor fuel for internal-combustion engines has injected some special features into refining methods. In order to remain mixed with gasoline, alcohol must be practically free from water and the mixture must be safeguarded against absorption of water from the air.

A new refinery for testing the economic possibilities of direct production of motor-fuel alcohol from corn has just been erected at Atchison, Kansas.

According to figures of the Treasury Department for 1935, the production of industrial alcohol from corn in the United States amounted to 5,984,285 gallons, and the production from blackstrap molasses amounted to 72,219,464 gallons. A considerable quantity was also produced from hydrol (waste corn sugar) and other by-products of the corn sugar industry. During this same period 95,748,303 gallons of denatured alcohol (all formulas) were produced, some of which represents a carry-over of stock as well as the utilization of off-grade alcohol or preliminary portions of the distillation which under existing regulations can not easily be re-refined. This applies more particularly to batch-distillation than continuous-distillation processes.

The yield of alcohol securable from corn depends on the percentage of fermentable matter present. With corn at 45 cents a bushel, and allowing a value of 5 cents a bushel for the by-products and a 6 cent conversion charge, the actual base production cost of 99.5 per cent alcohol would be about 24 cents per gallon, on the basis of a yield of 2.36 gallons per bushel.

The Cornstalk Industry

It has long been known that paper of good quality can be made out of cornstalks, but with wood pulp at its present prices, this use has not fallen within the range of economic

possibilities. Recently a plant was started at Danville, Illinois, which attempted to produce paper from cornstalks and finally failed because of the economic difficulties encountered. It has been demonstrated that not only good paper but also rayon can be made out of cornstalks. A coöperative investigation between the Iowa State College and the Bureau of Standards, conducted at Ames, Iowa, has proved that wall board from this material is a further possibility. The Maizewood Products Corporation of Dubuque, Iowa, is now engaged in the production of cornstalk wall board. It is estimated that cornstalks for this purpose cost about $11 to $14 delivered at the Dubuque plant.

The possibilities in the cornstalk industry will be greater as our timber resources become less. Wall board made from cornstalks is a good building material, but a widespread cornstalk industry should not be built up unless adequate provision is made for preventing the rapid inroads on soil fertility which such an industry will make. A ton of stalk contains as much nitrogen as a ton of manure, 50 per cent more phosphorus and twice as much potassium. This manure is worth $2 a ton. Farmers should not sell their cornstalks unless they can net $2 a ton after all expenses are paid.

Miscellaneous Products

There are a number of interesting uses for the by-products of the corn crop. Among these is the manufacture of corncob pipes. In south central Missouri is grown one of the largest-eared varieties of corn in existence. The cobs of this Missouri pipe variety sell to the pipe factory for about as much as ordinary ear corn which carries the kernels as well as the cobs. About $500,000 worth of Missouri cob pipes are sold annually.

Corncobs also serve as a source for furfural, which is extensively used in the manufacture of plastics and as a decolorizing solvent. Other agricultural by-products have, how-

ever, been found which are better adapted to the manufacture of furfural. Other minor miscellaneous uses, such as the manufacture of abrasives and adhesives from corncobs, have also been attempted.

SELECTED LIST OF REFERENCES

SWEENEY, O. R. The Commercial Utilization of Corncobs. Iowa Eng. Exp. Sta. 1924.

KEITH, M. HELEN. A Bibliography of Researches Bearing on the Composition and Nutritive Value of Corn and Corn Products. Ill. Bul. 257. 1925.

PHILLIPS, C. L., and BOERNER, E. G. Uses and Products Made of Corn. Grain Inv. Bur. of Agr. Econ. U. S. D. A. 1925 and Sup.

ROMMEL, G. M. Farm Products in Industry. Rae D. Henkle Co. N. Y. 1928.

WEBBER, H. A. Cellulose from Cornstalks. Ind. and Eng. Chem. Vol. 21. No. 3. Pp. 270-5. 1929.

CHAPTER XXVI

PROBLEMS AND COMMUNITY STUDIES

THIS chapter is especially for high school and college students who want to find the way corn is being grown in their home communities and to discover methods of improvement. First, some of the simple arithmetical problems which arise out of corn growing are considered, and after that community studies of corn.

PROBLEMS IN CORN GROWING

1. Determine the number of hills in an acre of corn when the hills are 3 feet 6 inches apart each way. When the hills are 3 feet 4 inches by 3 feet 6 inches. When the hills are 3 feet 4 inches each way. When the hills are 3 feet each way.

Suggestions:

There are 43,560 square feet in an acre. Each hill occupies 9 square feet when the hills are 3 feet apart each way.

2. If 3 kernels to the hill ordinarily gives an average of 2.6 stalks to the hill, about how many stalks will there be on an acre with hills 3 feet 6 inches apart planted at the 3 rate? How many stalks to the acre will three plantings give with the other distances as suggested under Problem 1? If there are only two stalks saved per hill how many stalks will there be per acre at different rates of planting?

3. With 10,000 stalks per acre how many ounces of ear corn must the average plant produce to make a yield of 30 bushels per acre? Of 40 bushels? Of 50 bushels? Of 70 bushels? Of 100 bushels? Answer these same questions but assume stands of 9000, 8000, 7000, and 6000 stalks per acre.

4. If a full-grown corn plant during mid-summer evaporates 5 pounds of water daily how many tons of water will an acre of 9000 corn plants evaporate in the 30-day period from July 10 to August 9?

5. If it takes 110 tons of water to make an acre-inch, about how many inches of water are represented by the monthly evaporation as under Problem 4?

6. If a bushel of soft corn on the ear weighs 90 pounds and is 25 per cent cob and 30 per cent water, how many pounds of dry feeding matter will there be in the grain of the 90 pounds? If a bushel of No. 2 corn on the ear weighs 70 pounds and is 20 per cent cob and 16 per cent water, how many pounds of dry feeding matter will there be in the shelled corn? If the 90 pounds of soft corn can be bought for 70 cents a bushel and the 70 pounds of No. 2 corn can be bought for 90 cents a bushel, which is the better buy for winter feeding, assuming the soft corn can be stored without spoiling?

7. How many miles will a man travel in cultivating an acre of corn with the rows 3 feet 6 inches apart if he uses a one-row cultivator? If he cultivates 7 acres in an 8-hour day, what is his rate of speed per hour? If he cultivates 12 acres with a two-row cultivator in an 8-hour day what is his rate of speed per hour?

8. Allowing 40 pounds to the cubic foot of settled silage, how many tons are there in 30 feet of settled silage in a 16-foot silo? Allowing 43 pounds to the bottom third of settled silage, how many tons are there in the bottom 9 feet of a 14-foot silo?

Studying Corn in a Community

In order to form practical corn judgment it is necessary to find out just how the practical farmers are growing corn in a community. It will be found that different farmers grow corn in different ways. In order to develop the direct contact between the student and the corn as it is actually grown, it is suggested that three different blanks should be filled out. To fill out the first blank the student should interview his father or some corn farmer in the neighborhood. Following is the first blank.

BLANK I

Collecting Corn Information from the Farmer Regarding a Particular Corn Field

What is the soil type?...

What crop was grown on this field last year?.............................

Two years ago?...

Three years ago?...

Four years ago?..................................

Five years ago?..................................

How much manure, lime or other fertilizer was spread on this field last year?.................. ....

Two years ago?.................................... ....

Three years ago?..................................

Four years ago?................................ .

Five years ago?...................................

Taking both soil type and soil treatment into account, what percentage is this field above or below average?........... ....

What variety of corn was planted on this field?.....................

Where did the seed corn come from originally? ....

Is it a big-eared, medium-eared, or small-eared type of corn? ....

How was the seed picked and stored?.......... ....

Ask the farmer for three ears illustrating the type of seed corn he likes....

Was the seed treated with commercial dust?.......................

When was the field planted?................................ .

How far apart each way were the hills spaced?............... ......

How many times was the corn cultivated?................. ....

What is the farmer's estimate of the yield per acre?.................

What was the rainfall and temperature like during the summer?........

Any particular items of interest offered by the farmer.............. ...

....

Too few farmers and farmers' boys give corn an intensive study in the field in September and October. The most important thing to be learned is whether the stand was too thick or too thin to utilize to the best advantage the soil fertility, the rainfall, and the type of corn. The information as to soil fertility, rainfall, type of corn, etc., is found in the answers to the questions of Blank I. The problem as set forth in Blank II is to go into the field and count the stalks in representative hills in different parts of the field and then finally to make an estimate of the total number of stalks in an acre. After weighing all of the information, a conclusion should finally be reached as to whether the stand in the particular field was toc thick or too thin in order to obtain the maximum yield of sound corn.

In the last part of Blank II will be noted the question, "How many pounds does the ear corn from fifty hills weigh?" When corn is thoroughly matured and it takes only 70 pounds

of ear corn to make a bushel and when the hills are 3 feet 6 inches apart each way, the number of pounds of ear corn from 50 representative hills gives a fairly accurate line on the number of bushels of yield per acre. In other words, if the ear corn from fifty hills weighs 60 pounds then it would be assumed that the field was yielding around 60 bushels to the acre. Of course in late September when the corn is so wet that it oftentimes takes 90 pounds of ear corn to make a bushel the yield of 38 or 39 hills of corn in pounds will come closer to giving the true yield in bushels per acre. It is an interesting school project to take a sample from a field of corn in late September or early October, weigh it immediately after it is taken from the field and then hang it up in a dry room and weigh it three weeks later after the water has dried out and then calculate the percentage of shrinkage.

Blank II which is based on the idea of using the corn field as the laboratory follows.

BLANK II

Collecting Corn Information about a Particular Field by Field Study in September and October

How many stalks are there in 70 representative hills?................

How many smutted stalks are there in 70 representative hills?.......

How many two-eared stalks are there in 70 representative hills?.....

How many barren stalks are there in 70 representative hills? ......

On the basis of the above sample how many stalks are there per acre? ...

On that basis, how many smutted stalks are there per acre? . .....

On the same basis how many two-eared stalks are there per acre?. ...

On the same basis, how many barren stalks are there per acre? . . .

How many pounds does the ear corn from 50 hills weigh?........ . .

How many pounds should be allowed to the bushel of ear corn at the time this weight is taken? ....

Allowing 70, 80, 90 or whatever number of pounds is about right, what is the indicated yield per acre from the 50-hill sample?..............

The questions in Blank III are best answered by the students during the winter months. The idea is to study crib-run corn as it exists in the average farmer's crib. One hundred

pounds of average corn should be taken out of the crib with a scoop shovel in such a way that there is an absolutely fair sample and this corn should be brought into the school house or some other place where the questions in Blank III can be answered. If the student, as a result of Blank I, is able to have on hand three ears illustrating the type of seed corn the farmer likes to plant, he will find it interesting to compare these with the field run. The seed ears, in the central part of the Corn Belt, will average about a pound in weight, whereas the average ear as it comes from the field will only average about a half a pound. The most important thing of all is to shell the corn and give it a commercial grade based on the moisture test and the test weight per bushel. Special apparatus is needed for determining both moisture and test weight per bushel. In case such apparatus is not available in the school it may be possible to have these points bearing on the government grade determined by sending a pound sample to some elevator or Board of Trade where there is the necessary equipment for making such tests. In some cases the tests may be made free of charge but in other cases as much as a dollar will be charged. Blank III follows.

BLANK III

Collecting Corn Information from 100 *Pounds of Average Crib-run Corn from a Specified Field*

How many ears are there in 100 pounds of crib-run corn?...............
What does the average ear weigh in ounces?.... ....
    How many of the ears weigh less than 5 ounces?..................
    How many of the ears weigh from 5 to 8 ounces?.................
    How many of the ears weigh over 8 ounces?.......................
How many of the ears carry 14 rows or less?.........................
    How many of the ears carry 16 rows?................ ....
    How many of the ears carry 18 rows?.........................
    How many of the ears carry 20 rows?.........................
    How many of the ears carry 22 rows or more?.....................
How many of the ears are smooth?..................................
How many of the ears are medium?..................................
How many of the ears are rough?...................................

What is the shelling percentage of the smooth ears?....................
Of the medium ears?..............................
Of the rough ears?..............................
What is the moisture percentage of the shelled corn from the smooth ears?
The medium ears?..............................
The rough ears?..............................
What is the test weight per bushel of the shelled corn from the smooth ears?
....
The medium ears?..............................
The rough ears?..............................
What is the commercial grade and probable price per bushel at Chicago of the shelled corn from the smooth ears?....................
The medium ears?..............................
The rough ears?..............................
How many kernels are there in an ounce of the shelled corn?............
Out of 100 representative kernels as taken from the sheller, how many are bright and shiny and how many are dull and starchy? .....

The most interesting information will come after the different students have filled out these different blanks and it is possible to tabulate side by side the information from at least half a dozen different cornfields. Then it is possible to make a detailed study to see to what extent the high-yielding fields owe their yield to a good stand and to what extent to soil fertility. It is interesting to study to what extent the high-yielding fields have the largest ears. Do the high-yielding fields have a higher percentage of smooth ears or a higher percentage of rough ears? To what extent does early planting influence the commercial grade of the corn? What is the influence of soil fertility on the commercial grade of the corn? In studying all of these things out, it will be found occasionally that there is no theory which adequately explains the results. Perhaps the students who fill out blanks of this sort will discover things which none of the professors and experimenters have ever known before.

Improving Community Practices

The teacher of vocational agriculture will find it worth while to stimulate community corn enterprises. Hitherto the easiest

thing to do has been to put on a corn show. Corn shows are all right as far as they go and they stir up considerable interest.

A new kind of corn show which vocational teachers can work out for themselves to fit their local situation is based on the idea of crib-run corn somewhat as presented under Blank III in this chapter. Let the competing corn be brought in on the ear just as it comes from the crib without any selection and then let it be shelled and finally judged on a shelled basis The standard of judgment would be the commercial grade and what the Chicago market would pay for it. In such a corn show, the shelling percentage, moisture determination, and test weight per bushel would ideally be done by the students in the high school. An exhibit might be held and in holding the exhibit the percentage of moisture, test weight per bushel, shelling percentage, etc., would be placed on each sample. It would be interesting, of course, if five or six ears which were not shelled could be exhibited along with these samples. These ears would of course have nothing to do with the determination of the awards but would merely give an idea as to how each man's corn looked on the ear.

Another community corn project which is very successful in years when the seed corn situation is bad is to do a considerable amount of rag-doll testing for different farmers during February and March. A conscientious teacher of vocational agriculture can oftentimes wake up a community to a grave seed corn danger by putting on a seed-corn testing campaign through his pupils.

Finally a corn meeting can be held in the late winter at which the results of the student study as obtained from Blanks I, II, and III can be set forth for the benefit of the practical farmer. And better yet the practical farmers can suggest ways in which the blanks can be improved to bring out ideas which the students have not discovered. Discussions can be held as to the proper number of stalks per acre to fit soils of different fertility in different kinds of seasons when planted with different types of corn.

A community enterprise which only a few vocational teachers will care to undertake is the seed corn cross-breeding project. The crossing of inbred strains of corn will from now on be coming more and more into the public eye. Certain vocational agricultural teachers who have a plot of ground convenient to the school will want to plant different inbred strains of corn and cross them in cooperation with some of the pupils. The seed thus crossed can be given in 2- or 3-pound lots to different farmers to try out the following year in comparison with their home varieties of corn.

A multitude of community corn projects will suggest themselves to the vocational agricultural teacher. In time he will discover certain things which are hidden to-day even from our most advanced research workers in corn.

SELECTED LIST OF REFERENCES

Blakeslee, A. F. Corn and Education. Jour. Heredity. Vol. VIII. No. 2. Pp. 51-7. 1917.

Hurd, E. B. The Corn Enterprise in Iowa. Iowa Bul. 259. 1929.

CHAPTER XXVII

CORN STATISTICS

Most of the statistics in the following are compiled from records of the United States Department of Agriculture. Students who wish to keep these tables up to date should consult future year-books and agricultural statistics of the United States Department of Agriculture and the monthly publication *Crops and Markets.*

The farm crops teacher, whether in high school or college, will find it possible to organize a number of research projects as the basis of these tables. For instance, the students can study for themselves the relationship between corn prices and corn yields as well as the relationship of weather records to corn yields. The geographical distribution of corn prices in different kinds of crop years can be investigated. We will call especial attention to the last table in this chapter dealing with corn quality in different years in Iowa and Ohio. The way in which this is influenced by weather is well worth careful study.

SELECTED LIST OF REFERENCES

Yearbooks and Agricultural Statistics (Annual). U. S. D. A.

Biennial Census of Manufactures (1929-31-33, etc.). Bureau of Census, U. S. Dept. of Com.

TABLE XXIII

CORN: PRODUCTION, WORLD AND SELECTED COUNTRIES, 1900–1901 TO 1935–1936

Crop Year	Estimated World Excluding Russia	Estimated Europe Excluding Russia	Selected Countries: United States	Danube Basin Countries	Argentina	Brazil	Russia [1]	Italy	Union of South Africa
	million bushels	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*
1900–01	3,750	445	2,662	269	99	. . .	34	88	2
1901–02	2,865	497	1,716	. . .	84	. . .	68	100	2
1902–03	3,841	391	2,774	. . .	149	. . .	49	71	2
1903–04	3,722	459	2,515	282	175	. . .	51	89	1
1904–05	3,663	279	2,687	113	141	. . .	26	90	11
1905–06	4,110	403	2,954	211	195	. . .	34	97	3
1906–07	4,230	533	3,033	370	72	. . .	92	93	2
1907–08	3,862	441	2,614	263	136	. . .	64	88	12
1908–09	3,811	465	2,567	287	177	. . .	82	96	10
1909–10	3,985	499	2,611	309	175	. . .	55	102	18
1910–11	4,118	564	2,853	375	28	. . .	102	104	31
1911–12	3,838	502	2,475	329	296	. . .	95	95	33
1912–13	4,271	547	2,948	. . .	197	. . .	94	101	34
1913–14	3,770	576	2,273	. . .	263	. . .	84	111	36
1914–15	4,041	558	2,524	. . .	325	[2]	90	105	40
1915–16	4,184	519	2,829	. . .	161	[3]	72	122	39
1916–17	3,635	389	2,425	. . .	59	204 [4]	62	82	43
1917–18	4,021	351	2,908	. . .	171	95	. . .	83	45
1918–19	3,517	299	2,441	. . .	224	87	. . .	77	41
1919–20	4,105	454	2,679	. . .	259	197	. . .	86	44
1920–21	4,551	519	3,071 [5]	354	230	186	46	89	48
1921–22	4,172	394	2,928	233	176	181	46	92	48
1922–23	4,044	424	2,707	275	176	202	118	77	71
1923–24	4,347	469	2,875	309	277	180	125	89	40
1924–25	3,886	589	2,298	404	186	162	92	106	87
1925–26	4,524	626	2,853	427	322	162	177	110	39
1926–27	4,360	653	2,575	468	321	164	136	118	65
1927–28	4,255	485	2,678	311	312	133	123	87	69
1928–29	4,247	384	2,715	250	252	194	130	65	67
1929–30	4,357	707	2,536	522	281	177	119	100	80
1930–31	3,959	612	2,065	400	420	187	105	118	57
1931–32	4,457	632	2,589	460	299	227	187	77	68
1932–33	4,826	765	2,907	555	268	238	135	119	30
1933–34	4,188	615	2,352	430	257	256	189	102	85
1934–35	3,432	729	1,377	507	451	228	151	126	63
1935–36 [6]	4,104	559	2,203	378	. . .	. .	. .	. .	.

Bureau of Agricultural Economics. Official sources and International Institute of Agriculture.

Production figures refer to the year of harvest Harvests of the northern hemisphere countries are combined with those of the southern hemisphere which immediately follow; thus for 1934–1935 the crop harvested in the northern hemisphere countries in 1934 is combined with the southern hemisphere harvest which takes place early in 1935.

[1] Includes all Russian territory reporting for the years shown.

[2] Total Russian Empire, exclusive of the 10 Vistula Provinces of Russian Poland and the Province of Batum in Transcaucasia.

[3] Exclusive of Russian Poland, Lithuania, parts of present Latvia and the Ukraine, and the Provinces of Batum and Elizabetpol in Transcaucasia

[4] Beginning this year, estimates within present boundaries of the Union of Soviet Socialist Republics, exclusive of Turkestan, Transcaucasia, and the Far East, which territory in 1924–1925 produced 26,048,000 bushels

[5] Production in present boundaries beginning this year, therefore not comparable with earlier years.

[6] Preliminary.

TABLE XXIV.—Corn: Domestic Exports from the United States by Countries, 1910–1935

Year Ended June 30	United Kingdom	Netherlands	Canada	Germany	Mexico	Cuba	Denmark	Belgium	France	Italy	Other Countries	Total
	thousand bushels	thousand bushels	thousand bushels	thousand bushels	thousand bushels	thousand bushels	thousand bushels	thousand bushels	thousand bushels	thousand bushels	thousand bushels	thousand bushels
1910	10,668	5,185	6,179	4,537	3,258	2,377	2,451	1,144	446	0	557	36,802
1911	17,723	7,147	13,410	7,971	7,067	2,225	3,083	2,681	1,626	51	777	63,761
1912	10,616	5,658	9,569	6,801	1,168	2,118	1,546	1,407	452	4	700	40,039
1913	14,983	7,192	8,098	6,546	543	2,373	5,390	1,648	442	4	1,846	49,065
1914	541	374	4,642	303	467	2,410	[1]	60	55	0	529	9,381
1915	2,850	15,876	8,283	16	1,587	2,267	11,170	104	3,773	70	2,790	48,786
1916	5,627	5,706	6,568	0	3,679	3,231	9,527	5	2,560	[1]	1,314	38,217
1917	24,494	7,924	15,725	0	2,531	2,819	7,075	581	1,533	1,157	882	64,721
1918	21,198	246	7,896	0	3,273	1,142	0	3,714	1,417	2,018	94	40,998
1919	2,522	100	8,940	0	1,215	1,454	334	1,568	2	350	203	16,688
1920	2,169	0	9,929	0	61	2,031	1	1	191	0	85	14,468
1921	11,423	10,144	20,298	10,844	5,635	2,121	4,401	955	165	27	898	66,911
1922	22,074	22,840	61,643	27,175	10,102	2,694	7,266	4,471	2,975	1,428	13,718	176,386
1923	21,271	13,962	32,154	11,807	288	2,778	3,320	1,931	3,174	861	2,418	94,064
1924	4,449	2,369	8,258	673	337	2,615	866	564	380	[1]	655	21,186
1925	141	77	4,239	26	1,366	2,267	0	0	5	[1]	339	8,460
1926	2,378	3,510	8,071	742	4,453	2,097	999	9	110	0	768	23,137
1927	1,268	560	10,536	2	2,124	2,016	553	69	12	24	399	17,563
1928	1,885	4,311	6,454	2,520	323	1,021	845	92	22	0	901	18,374
1929	8,237	6,262	11,082	4,241	572	765	896	688	982	2,587	4,432	40,744
1930	20	126	7,390	[1]	1,297	226	[1]	1	14	[1]	280	9,354
1931	13	50	1,226	69	756	47	1	2	16	[1]	179	2,359
1932	323	65	2,681	114	7	2	0	31	51	0	70	3,344
1933	1,001	759	5,183	156	9	47	197	519	153	[1]	169	8,193
1934	263	154	3,627	58	7	58	[1]	8	54	[1]	176	4,405
1935	12	2	1,791	[1]	1	[1]	[1]	[1]	11	0	39	1,856
1936	.				.		.	. ...	. .		. . .	. . .
1937	. .		. .			.	. .	. .	.	.	. . .	.
1938		.	. . .				.		.		. ....	.
1939												

Bureau of Agricultural Economics Compiled from Foreign Commerce and Navigation of the United States, 1910–1918, Monthly Summary of Foreign Commerce of the United States, June issues, and official records of the Bureau of Foreign and Domestic Commerce, 1927–1935, inclusive.

[1] Less than 500 bushels.

Note: The decline in exports from the United States to the United Kingdom has been accompanied by an increase in imports into the United Kingdom chiefly from Argentina, as follows:

Year	Bushels	Year	Bushels	Year	Bushels
1926	51,000,000	1930	45,000,000	1932	91,000,000
1928	49,000,000			1934	108,000,000

TABLE XXV.—CORN: ACREAGE IN THE CORN BELT STATES AND UNITED STATES, 1866–1935

Year	Ohio	Indiana	Illinois	Minnesota	Iowa	Missouri	South Dakota	Nebraska	Kansas	United States
	thousand acres	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*
1866	2,500	1,950	4,925	120	1,810	1,520	....	72	217	30,017
1867	2,400	1,975	5,075	130	1,810	1,750	....	90	260	32,134
1868	2,350	2,075	5,650	150	1,890	1,910	....	115	340	35,135
1869	2,450	2,050	5,600	156	2,080	2,160	....	125	445	35,850
1870	2,600	2,325	6,350	190	2,550	2,590	....	155	570	38,408
1871	2,850	2,500	6,730	225	3,060	2,980	....	225	860	42,029
1872	2,800	2,600	6,860	245	3,360	3,340	....	295	1,160	43,618
1873	2,750	2,550	6,850	240	3,600	3,540	....	370	1,371	44,124
1874	2,900	2,850	7,425	295	4,150	4,070	....	380	1,740	47,686
1875	3,250	3,175	8,150	350	4,600	4,760	....	625	2,206	52,504
1876	3,500	3,500	8,500	350	5,200	4,975	....	780	2,105	55,347
1877	3,425	3,675	8,950	410	5,800	5,025	....	1,130	2,926	58,892
1878	3,450	3,700	8,425	405	6,100	5,075	....	1,340	2,745	59,768
1879	3,282	3,678	9,019	439	6,616	5,588	....	1,631	3,418	62,354
1880	3,150	3,425	8,840	495	6,950	5,650	....	1,970	3,726	62,699
1881	3,050	3,450	9,100	560	6,530	5,650	....	2,150	4,200	63,191
1882	3,100	3,350	8,800	750	6,740	5,760	179	2,460	4,662	66,157
1883	3,050	3,450	9,050	645	7,000	5,880	259	2,990	5,129	68,168
1884	3,075	3,525	8,640	660	7,360	6,000	446	3,500	4,960	68,834
1885	3,275	3,650	8,900	720	7,580	6,300	509	3,910	5,456	71,854
1886	3,175	3,650	8,900	750	7,960	6,480	636	4,380	6,301	73,911
1887	3,200	3,700	8,140	820	8,120	6,400	611	4,740	5,666	73,296
1888	3,450	3,850	8,630	870	8,440	6,540	630	5,120	7,566	77,474
1889	3,350	3,775	8,900	925	8,610	6,800	786	5,480	7,319	77,656
1890	3,300	3,875	9,300	965	8,790	6,860	850	5,525	3,807	74,785
1891	3,350	3,975	9,700	935	9,040	6,800	980	6,150	5,386	78,855
1892	3,300	3,725	8,720	905	7,860	6,250	835	5,975	5,791	76,914
1893	3,450	3,900	9,150	1,035	8,180	6,500	910	6,400	6,391	79,832
1894	3,600	4,100	9,520	1,100	8,750	7,010	375	6,825	3,576	80,069
1895	3,775	4,300	10,000	1,360	9,070	7,200	1,180	7,300	8,400	90,479
1896	4,000	4,500	9,925	1,405	9,160	7,125	1,260	7,425	8,008	89,074
1897	3,800	4,400	10,500	1,320	9,020	7,500	1,070	7,500	8,408	89,965
1898	3,900	4,375	9,760	1,410	8,660	7,250	1,080	7,000	7,315	87,784
1899	3,860	4,568	10,060	1,442	8,840	7,480	1,225	7,380	8,266	94,591

1900	4,000	5,025	10,460	1,480	9,100	7,700	1,280	7,350	7,472	94,852
1901	3,875	5,050	10,700	1,610	9,460	7,550	1,450	7,175	6,836	94,422
1902	4,000	5,225	10,850	1,800	9,560	7,550	1,660	7,350	7,140	97,177
1903	3,900	5,150	10,550	1,790	8,410	7,050	1,700	7,075	6,707	93,555
1904	3,975	5,450	10,500	1,950	9,550	6,650	1,750	7,275	6,707	95,228
1905	3,750	5,000	10,500	1,940	9,600	7,080	1,830	7,200	7,042	95,746
1906	3,900	5,075	10,500	1,990	9,650	6,980	1,875	7,075	6,819	95,624
1907	3,800	4,950	10,400	1,950	9,700	7,080	1,850	7,075	7,087	96,094
1908	3,750	4,875	9,800	2,010	9,350	6,500	1,940	7,150	7,386	95,285
1909	4,030	5,095	10,173	2,067	9,401	7,220	2,068	7,327	8,109	100,200
1910	3,925	4,950	10,150	2,190	9,530	7,500	2,150	7,425	8,950	102,267
1911	3,900	4,950	9,800	2,430	9,850	7,400	2,350	7,350	8,157	101,393
1912	3,950	5,050	10,000	2,610	9,920	7,610	2,650	7,500	7,575	101,451
1913	3,850	5,100	9,850	2,720	9,720	7,480	2,825	7,650	7,320	100,206
1914	3,725	5,150	9,650	3,025	9,850	7,370	3,150	7,350	5,850	97,796
1915	3,800	5,250	9,500	3,090	9,900	7,220	3,250	7,350	5,550	100,623
1916	3,900	5,330	9,550	2,860	9,800	7,400	3,000	7,600	6,950	100,561
1917	4,200	5,875	10,100	3,230	10,500	8,020	3,350	8,350	9,156	110,893
1918	3,875	5,350	9,650	3,010	9,800	7,300	3,240	7,000	6,130	102,195
1919	4,047	5,172	8,650	3,258	9,959	6,272	3,408	7,080	4,370	98,145
1920	3,925	5,320	9,169	3,747	10,300	6,646	3,875	7,660	5,331	101,359
1921	3,730	5,040	8,912	3,859	10,250	6,095	3,992	7,520	4,638	103,155
1922	3,581	4,960	8,377	4,052	10,364	6,250	4,071	7,440	5,195	100,345
1923	3,653	5,295	8,628	4,376	10,776	6,562	4,493	8,500	5,713	101,123
1924	3,432	4,688	8,946	4,595	10,912	6,300	4,814	8,718	6,056	100,420
1925	3,707	4,922	9,393	4,273	11,234	6,741	4,765	9,200	6,722	101,331
1926	3,596	4,824	9,205	4,529	11,195	6,471	4,755	9,290	5,781	99,452
1927	3,344	4,293	8,469	4,302	10,980	5,796	4,955	9,160	6,241	98,357
1928	3,612	4,636	9,231	4,216	11,300	6,260	4,850	9,250	6,988	100,336
1929	3,473	4,253	8,575	4,359	11,048	5,566	5,095	9,516	6,643	97,806
1930	3,438	4,466	9,004	4,533	11,335	6,345	5,146	9,564	6,776	101,083
1931	3,576	4,734	9,544	4,896	11,732	6,472	4,837	10,042	6,573	105,948
1932	3,433	4,639	9,353	4,945	11,849	6,472	5,030	10,644	7,362	108,668
1933	3,364	4,314	8,324	4,846	11,375	6,019	3,873	10,431	6,994	103,260
1934	2,927	3,883	7,159	4,507	8,986	4,815	2,827	6,676	3,777	87,795
1935 [1]	3,190	4,038	7,589	4,507	9,525	3,879	3,732	7,820	4,608	92,727

Bureau of Agricultural Economics. Compiled from records of the Division of Crop and Livestock Estimates.

[1] Preliminary.

TABLE XXVI

Corn: Yield per Acre in the Corn Belt States and United States, 1866–1935

Year	Ohio	Indiana	Illinois	Minnesota	Iowa	Missouri	South Dakota	Nebraska	Kansas	United States
	bushels	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*
1866	37.0	36.5	29.0	23.0	32.0	26.0	...	29.5	28.0	24.3
1867	30.0	29.0	27.0	35.0	41.0	32.0	...	38.0	38.5	24.7
1868	35.0	34.0	34.0	37.0	40.5	26.5	...	28.0	20.0	26.2
1869	30.0	25.5	23.5	29.0	33.5	30.6	...	38.5	38.5	21.8
1870	39.0	39.5	40.0	31.5	40.0	34.0	...	33.5	28.0	29.3
1871	39.0	35.5	33.0	35.5	43.5	35.5	...	38.0	36.5	27.2
1872	40.0	38.5	39.8	33.5	41.0	31.5	...	37.0	36.0	29.3
1873	35.0	30.0	21.0	31.0	32.5	23.5	...	22.0	23.5	22.9
1874	37.0	34.0	24.0	29.5	34.0	16.0	...	15.0	10.5	22.2
1875	34.5	32.0	34.5	25.0	35.0	36.0	...	31.0	34.5	27.6
1876	37.5	35.0	30.0	26.0	34.0	28.0	...	32.0	35.0	26.7
1877	32.5	35.0	27.0	26.5	33.5	29.0	...	34.0	34.0	25.7
1878	36.0	32.0	29.0	36.5	40.5	26.0	...	41.0	28.5	26.2
1879	34.1	31.4	36.1	33.8	41.6	36.2	...	40.1	30.9	28.1
1880	39.0	25.5	31.0	31.0	39.5	28.5	...	31.0	29.5	27.2
1881	31.0	22.0	21.0	31.0	30.0	16.5	...	29.5	18.0	19.7
1882	34.0	34.0	25.0	27.0	30.5	33.5	25.0	38.0	33.5	26.5
1883	26.0	29.0	27.5	21.0	29.0	28.0	20.0	37.5	36.5	24.2
1884	33.0	31.0	33.0	32.0	39.5	34.0	30.0	41.0	37.0	28.3
1885	39.0	36.0	34.5	28.0	36.5	31.5	29.0	40.0	32.5	28.6
1886	34.0	34.0	28.0	31.0	29.0	24.0	21.5	31.0	22.0	24.1
1887	31.0	22.0	21.0	27.0	30.0	23.0	27.0	27.5	14.5	21.9
1888	38.5	37.0	40.0	28.0	39.5	31.0	25.5	38.0	26.5	29.1
1889	35.7	30.4	36.8	27.4	41.3	32.4	17.5	39.4	35.5	29.5
1890	25.0	25.0	28.0	27.0	28.0	28.0	13.5	20.0	10.5	22.1
1891	37.5	36.0	38.0	26.5	40.5	30.0	27.0	37.5	26.5	29.6
1892	31.0	31.0	27.0	27.0	30.5	28.0	27.0	32.0	24.5	24.7
1893	29.0	24.0	26.0	28.0	37.5	30.5	30.0	26.5	21.5	23.8
1894	30.5	30.0	31.0	18.5	15.0	24.0	4.0	7.0	11.0	20.2
1895	33.5	36.0	41.0	30.5	39.0	37.0	11.0	16.5	24.5	28.0
1896	42.0	39.5	42.0	30.5	43.0	29.5	30.0	37.5	28.0	30.0
1897	35.0	30.5	34.0	28.0	33.5	26.0	27.0	30.0	19.0	25.4
1898	40.0	38.5	31.0	30.5	36.0	30.0	28.0	21.0	19.0	26.8
1899	39.7	39.8	38.8	32.8	39.1	28.1	27.1	28.8	27.8	28.0

1900	42.5	41.5	40.0	33.0	45.0	29.5	27.0	26.0	19.0	28.1
1901	30.0	22.0	24.0	27.0	28.5	10.0	21.0	14.0	8.0	18.2
1902	40.0	39.0	41.0	23.0	38.0	39.0	19.0	32.5	30.0	28.5
1903	32.5	35.0	35.5	27.5	32.5	29.5	25.0	27.5	26.0	26.9
1904	35.5	33.0	39.0	25.5	39.0	26.0	23.0	33.0	21.0	28.2
1905	39.5	42.0	42.0	34.0	41.5	34.0	30.5	34.0	28.0	30.9
1906	43.0	41.0	39.0	34.0	45.5	32.5	30.5	34.0	29.0	31.7
1907	36.0	36.5	39.0	27.0	35.0	31.0	21.5	24.0	22.0	27.2
1908	38.5	30.5	35.0	29.0	38.0	27.0	26.0	27.0	22.0	26.9
1909	40.2	39.9	38.8	33.9	37.1	26.9	27.3	24.8	19.1	26.1
1910	36.5	39.0	41.0	32.0	41.5	33.0	21.0	26.0	19.0	27.9
1911	39.5	34.5	36.0	33.0	35.5	26.0	19.5	21.5	14.5	24.4
1912	41.5	39.5	40.0	34.0	46.0	32.0	26.5	27.0	23.0	29.1
1913	37.5	35.5	28.0	38.0	37.5	17.5	22.5	15.0	3.0	22.7
1914	39.0	33.0	31.0	35.0	40.5	22.0	22.0	24.5	18.5	25.8
1915	40.5	38.5	38.0	23.0	32.5	29.5	26.0	31.0	31.0	28.1
1916	31.5	32.5	31.0	33.0	38.0	19.5	24.5	27.0	10.0	24.1
1917	37.0	35.5	40.0	27.0	38.5	33.5	24.0	27.0	13.0	26.2
1918	36.0	35.0	36.5	37.0	37.0	20.0	30.0	18.0	7.0	23.9
1919	41.5	35.6	36.0	35.5	41.6	26.5	25.5	24.0	15.5	27.3
1920	40.0	39.5	35.0	33.5	46.0	31.5	30.0	33.2	26.2	30.3
1921	39.5	36.0	35.0	38.5	43.0	30.5	32.0	27.0	22.8	28.4
1922	37.0	36.0	35.5	29.5	45.0	28.5	28.5	24.0	19.0	27.0
1923	40.0	38.0	37.5	35.0	40.5	30.0	32.0	32.0	23.0	28.4
1924	27.0	26.5	33.0	26.5	28.0	26.5	21.3	22.5	23.5	22.9
1925	46.0	43.5	42.0	34.5	43.9	30.0	17.5	25.0	17.6	28.2
1926	38.5	38.0	36.0	32.0	39.0	27.5	18.0	15.5	11.0	25.9
1927	33.0	31.5	31.5	28.5	35.0	29.0	30.0	32.1	30.0	27.2
1928	35.5	35.2	38.4	33.0	41.5	30.0	21.0	22.0	27.0	27.1
1929	34.5	31.0	35.5	36.0	40.2	23.5	23.7	25.5	17.5	25.9
1930	25.5	26.2	26.0	31.0	34.0	14.0	16.0	25.0	12.0	20.4
1931	45.0	39.0	37.0	23.5	32.9	27.5	5.2	17.0	17.5	24.4
1932	35.5	37.5	43.0	36.5	43.0	30.5	14.7	25.3	18.5	26.8
1933	33.5	29.5	27.0	29.5	40.0	23.5	10.6	22.5	11.5	22.8
1934	31.5	24.8	20.5	17.0	21.8	5.5	4.5	3.2	2.8	15.7
1935 [1]	42.0	38.0	38.0	33.0	37.0	19.0	14.0	13.5	7.5	23.8

Bureau of Agricultural Economics. Compiled from records of the Division of Crop and Livestock Estimates.

[1] Preliminary.

TABLE XXVII

Corn: Production in the Corn Belt States and United States, 1866–1935

Year	Ohio	Indiana	Illinois	Minnesota	Iowa	Missouri	South Dakota	Nebraska	Kansas	United States
	million bushels	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*
1866	92	71	143	3	58	40	....	2	6	731
1867	72	57	137	5	74	56	.....	3	10	794
1868	82	71	193	6	77	51	.....	3	7	920
1869	74	52	132	5	70	66	.....	5	17	782
1870	101	92	254	6	102	88	.....	5	16	1,125
1871	111	89	222	8	133	106	.....	9	31	1,142
1872	112	100	273	8	138	105	...	11	42	1,279
1873	96	76	144	7	117	83	.....	8	32	1,008
1874	107	97	178	9	141	65	.....	6	18	1,059
1875	112	102	280	9	161	171	.....	19	76	1,450
1876	131	122	255	9	177	139	.....	25	74	1,478
1877	111	129	242	11	194	146	.....	38	99	1,516
1878	124	118	244	15	247	132	....	55	78	1,565
1879	112	115	326	15	275	202	.....	65	106	1,752
1880	123	87	274	15	275	161	.....	61	110	1,707
1881	95	76	191	17	196	93	...	63	76	1,245
1882	105	114	220	20	206	193	4	93	156	1,755
1883	79	100	247	14	203	165	5	112	187	1,651
1884	101	109	285	21	291	204	13	144	184	1,948
1885	128	131	307	20	277	198	15	156	177	2,058
1886	108	124	247	23	231	156	14	136	139	1,783
1887	99	81	171	22	244	147	16	130	82	1,605
1888	133	142	345	24	333	203	16	195	200	2,251
1889	120	115	328	25	356	220	14	216	260	2,294
1890	82	97	260	26	246	192	11	110	40	1,650
1891	126	143	369	25	366	204	26	231	143	2,336
1892	102	115	235	24	240	175	23	191	142	1,897
1893	100	94	238	29	307	198	27	170	137	1,900
1894	110	123	295	20	131	168	2	48	39	1,615
1895	126	155	410	41	354	266	15	120	206	2,535
1896	168	178	417	43	394	210	38	278	224	2,671
1897	133	134	357	37	302	195	29	225	160	2,287
1898	156	168	303	43	312	218	30	147	139	2,351
1899	153	182	390	47	346	210	33	213	230	2,646

1900	170	209	418	49	410	227	35	191	142	2,662
1901	116	111	257	43	270	76	30	100	55	1,716
1902	160	204	445	41	363	294	32	239	214	2,774
1903	127	180	375	49	273	208	42	195	174	2,515
1904	141	180	410	50	372	173	40	240	141	2,687
1905	148	210	441	66	398	241	56	245	197	2,954
1906	168	208	410	68	439	227	57	241	198	3,033
1907	137	181	406	53	340	219	40	170	156	2,614
1908	144	149	343	58	355	176	50	193	162	2,567
1909	162	203	395	70	349	194	56	182	155	2,611
1910	143	193	416	70	395	248	45	193	170	2,853
1911	154	171	353	80	350	192	46	158	118	2,475
1912	164	199	400	89	456	244	70	202	174	2,948
1913	144	181	276	103	364	131	64	115	22	2,273
1914	145	170	299	106	399	162	69	180	108	2,524
1915	154	202	361	71	322	213	84	228	172	2,829
1916	123	174	296	94	372	144	74	205	70	2,425
1917	155	209	404	87	404	269	80	225	119	2,908
1918	140	187	352	111	363	146	97	126	43	2,441
1919	168	184	311	116	414	166	87	170	68	2,679
1920	157	210	321	126	474	209	116	254	140	3,071
1921	147	181	312	149	441	186	128	203	106	2,928
1922	132	179	297	120	466	178	116	179	99	2,707
1923	146	201	324	153	436	197	144	272	131	2,875
1924	93	124	295	122	306	167	103	196	142	2,298
1925	171	214	395	147	493	202	83	230	118	2,853
1926	138	183	331	145	437	178	86	144	64	2,575
1927	110	135	267	123	384	168	149	294	187	2,678
1928	128	163	354	139	469	188	102	204	189	2,715
1929	120	132	304	157	444	131	121	243	116	2,536
1930	88	117	234	141	385	89	82	239	81	2,065
1931	161	185	353	115	386	178	25	171	115	2,589
1932	122	174	402	180	510	197	74	269	136	2,907
1933	113	127	225	143	455	141	41	235	80	2,352
1934	92	96	147	77	196	26	13	21	11	1,377
1935 [1]	134	153	288	149	352	74	52	106	35	2,203

Bureau of Agricultural Economics. Compiled from records of the Division of Crop and Livestock Estimates.

[1] Preliminary.

TABLE XXVIII

CORN: MONTHLY MARKETINGS,[1] UNITED STATES, 1907–1908 TO 1934–1935

Crop Year Beginning October	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Year
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1907–08	3.5	8.1	11.2	13.0	14.7	12.6	6.5	5.1	5.3	6.1	6.2	7.7	100.0
1908–09	6.9	7.5	12.4	15.3	7.4	7.7	8.4	8.2	6.2	5.8	6.8	7.4	100.0
1909–10	8.3	10.5	14.1	13.7	10.8	6.4	4.5	8.0	6.6	4.7	6.3	6.1	100.0
1910–11	7.0	10.7	16.0	12.4	10.3	8.6	5.3	8.0	6.7	4.8	5.7	4.5	100.0
1911–12	5.5	12.5	15.1	14.4	11.6	7.3	6.4	6.4	5.5	4.1	5.1	6.1	100.0
1912–13	6.6	10.7	17.2	13.5	12.8	6.0	4.3	7.1	7.9	5.9	3.4	4.6	100.0
1913–14	7.7	17.4	20.9	10.5	7.0	6.2	4.3	6.1	4.5	3.8	7.0	4.6	100.0
1914–15	4.6	14.4	16.4	19.3	7.6	4.5	5.5	4.3	5.8	5.5	5.8	6.3	100.0
1915–16	5.9	10.3	15.7	11.6	12.3	7.0	6.3	6.2	5.8	6.1	7.0	5.8	100.0
1916–17	5.7	15.0	13.4	16.1	9.6	7.5	5.8	6.9	6.4	5.7	4.3	3.6	100.0
1917–18	3.5	8.1	11.2	13.0	14.7	12.5	6.5	5.1	5.3	6.1	6.3	7.7	100.0
1918–19	7.2	7.9	12.9	16.1	7.7	8.1	8.8	8.6	6.6	4.8	6.0	5.3	100.0
1919–20	5.4	8.9	14.6	12.6	9.2	8.5	5.7	7.4	10.3	5.3	5.4	6.7	100.0
1920–21	5.2	6.9	10.9	13.9	11.4	8.6	5.4	8.3	9.1	4.8	7.1	8.4	100.0
1921–22	6.5	6.4	12.1	13.5	12.1	7.3	4.6	7.4	7.3	6.6	7.3	8.9	100.0
1922–23	8.5	9.0	14.1	11.1	11.4	6.8	5.5	6.3	6.6	7.0	7.4	6.3	100.0
1923–24	5.6	10.5	12.4	13.0	13.4	7.5	6.1	5.9	6.0	6.7	6.3	6.6	100.0
1924–25	7.0	11.2	13.1	13.7	9.6	8.2	6.3	7.9	4.3	5.1	7.7	5.9	100.0
1925–26	5.9	9.3	14.7	12.1	10.4	8.5	5.3	7.1	8.2	5.7	6.2	6.6	100.0
1926–27	10.2	9.2	13.0	11.8	10.9	6.9	4.8	6.1	9.2	5.1	6.5	6.3	100.0
1927–28	6.3	8.7	15.6	13.9	11.8	9.0	5.4	6.7	5.4	5.9	5.9	5.4	100.0
1928–29	6.3	12.0	16.1	12.4	11.0	7.1	3.7	4.1	7.0	6.3	6.7	7.3	100.0
1929–30	6.9	9.2	13.3	10.8	10.5	7.3	7.0	6.9	6.3	6.0	7.9	7.9	100.0
1930–31	7.5	9.3	13.0	10.0	9.9	8.2	7.7	5.5	7.5	7.4	8.2	5.8	100.0
1931–32	7.6	9.9	11.2	10.2	10.4	7.6	7.4	6.4	5.4	6.2	8.6	9.1	100.0
1932–33	8.3	8.1	8.9	8.0	7.4	5.1	8.4	9.1	10.3	12.4	6.2	7.8	100.0
1933–34	8.8	10.9	9.6	8.0	6.5	6.7	3.6	5.1	6.4	10.8	14.8	8.8	100.0
1934–35	11.6	11.3	11.3	7.9	7.4	7.2	8.8	7.7	7.6	6.4	6.7	6.1	100.0

Bureau of Agricultural Economics Compiled from records of the Division of Crop and Livestock Estimates.

[1] Estimated marketings of corn by farmers as a percentage of the year's receipts reported by about 3500 mills and elevators.

TABLE XXIX

CORN: UTILIZATION FOR GRAIN, SILAGE, HOGGING DOWN, GRAZING, AND FORAGE, 1919–1935

Year	For Grain		For Silage		Hogging down, Grazing and Forage Acreage
	Acreage	Production	Acreage	Production	
	thousand acres	*thousand bushels*	*thousand acres*	*thousand tons*	*thousand acres*
1919	87,487	2,341,870	3,554	......	7,104
1920	90,149	2,695,085	3,682	......	7,528
1921	91,939	2,556,924	3,486	......	7,730
1922	84,858	2,229,496	3,663	......	11,824
1923	87,493	2,429,551	3,983	......	9,647
1924	84,119	1,899,751	4,906	......	11,995
1925	86,918	2,413,364	3,596	......	10,817
1926	83,097	2,133,404	4,346	......	12,009
1927	83,915	2,249,926	4,268	......	10,174
1928	85,821	2,282,938	3,996	......	10,519
1929	83,196	2,140,215	4,021	29,342	10,589
1930	85,465	1,733,429	4,845	30,461	10,773
1931	90,055	2,229,088	4,704	33,434	11,189
1932	94,585	2,514,613	4,063	30,816	10,020
1933	88,999	2,038,706	4,541	31,115	9,720
1934	58,432	1,104,657	6,678	33,466	22,685
1935[1]	80,291	1,923,559	4,565	33,370	7,968

Bureau of Agricultural Economics. Compiled from records of the Division of Crop and Livestock Estimates.

[1] Preliminary.

TABLE XXX

POPCORN: ACREAGE, YIELD, PRODUCTION, PRICE PER HUNDRED POUNDS, AND VALUE, IOWA, 1912–1935

Year	Acreage Harvested	Yield per Acre	Production	Farm Price to Dec. 1[1]	Value, Basis Dec. 1 Price
	acres	*pounds* [2]	*thousand pounds*	*dollars*	*thousand dollars*
1912	19,300	2,350	45,355	....	.....
1913	18,200	2,025	36,855	....	.....
1914[3]	......	.....	......	....	.....
1915	5,600	1,245	6,972	....	.....
1916	15,700	2,165	33,990	....	.....
1917	18,000	1,455	26,190	....	.....
1918	27,900	1,320	36,828	5.90	2,173
1919	35,000	1,960	68,600	5.40	3,704
1920	17,300	1,700	29,410	4.60	1,353
1921	6,700	2,050	13,735	3.60	494
1922	9,800	1,770	17,346	3.00	520
1923	20,600	1,890	38,934	5.50	2,141
1924	23,800	1,250	29,750	3.00	892
1925	54,100	1,685	91,158	3.00	2,735
1926	29,400	1,450	42,630	2.70	1,151
1927	17,500	1,665	29,138	2.50	728
1928	20,700	1,710	35,397	2.50	885
1929	26,300	1,525	40,108	2.80	1,123
1930	41,200	1,235	50,882	2.80	1,425
1931	19,400	1,230	23,862	2.00	477
1932	15,000	1,670	25,050	1.25	313
1933	6,700	1,700	11,390	1.00	114
1934	12,400	415	5,146	5.00	257
1935[4]	15,000	1,200	18,000	2.10	378

Bureau of Agricultural Economics. Compiled from the records of the Division of Crop and Livestock Estimates. Data are based chiefly on state assessors' acreage enumerations and special field inquiries.

[1] On the ear.

[2] Of ear corn; 70 pounds to a bushel.

[3] Not reported.

[4] Preliminary.

NOTE: 1935 acreage in popcorn in Nebraska 17,000 and in Kansas 14,000.

TABLE XXXI

CORN: AVERAGE PRICE PER BUSHEL RECEIVED BY PRODUCERS, CORN BELT STATES AND UNITED STATES, DECEMBER 1, 1891–1935

Year	Ohio	Ind.	Ill.	Minn.	Iowa	Mo.	S. Dak.	Nebr.	Kans.	United States
	cents	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*
1891	41	38	37	39	30	38	35	26	34	40.6
1892	42	40	37	37	32	36	33	28	31	39.4
1893	40	36	31	34	27	30	25	27	31	36.5
1894	43	37	39	43	45	40	46	50	43	45.7
1895	27	23	22	20	18	20	23	18	19	25.3
1896	21	19	18	19	14	20	18	13	18	21.5
1897	25	21	21	24	17	24	21	17	22	26.3
1898	27	25	25	24	23	27	23	22	26	28.7
1899	30	27	26	24	23	30	26	23	25	30.3
1900	34	32	32	29	27	32	29	31	32	35.7
1901	57	55	57	45	52	67	45	54	63	60.5
1902	42	36	36	40	33	33	41	30	34	40.3
1903	47	36	36	38	38	34	35	28	36	42.5
1904	46	41	39	36	33	44	36	33	41	44.1
1905	43	38	38	33	34	37	31	32	33	41.2
1906	39	36	36	34	32	38	29	29	32	39.9
1907	52	45	44	50	43	47	46	41	44	51.6
1908	63	60	57	55	52	57	50	51	55	60.6
1909	56	50	52	49	49	59	50	50	54	57.9
1910	46	40	38	45	36	44	40	36	45	48.0
1911	58	54	55	53	53	60	53	55	63	61.8
1912	45	42	41	37	35	46	37	37	40	48.7
1913	63	60	63	53	60	74	56	65	78	69.1
1914	61	58	61	52	55	68	50	53	63	64.4
1915	56	51	54	62	51	57	49	47	51	57.5
1916	90	84	84	80	80	90	77	78	90	88.9
1917	136	125	110	110	108	114	120	120	125	127.9
1918	130	119	120	111	122	143	110	128	149	136.5
1919	121	125	130	120	120	138	119	122	140	134.2
1920	68	59	59	51	47	64	42	41	44	65.6
1921	41	37	38	31	30	40	26	27	31	41.3
1922	66	56	60	56	56	68	50	58	61	65.0
1923	74	62	65	61	62	74	52	53	64	71.3
1924	104	94	95	85	93	96	80	91	87	97.8
1925	57	55	58	56	56	69	60	61	66	67.0
1926	60	50	56	56	56	68	58	68	70	63.8
1927	77	68	71	64	69	75	57	62	61	71.8
1928	76	69	70	62	67	73	62	71	65	74.6
1929	78	74	72	65	70	86	62	69	74	77.4
1930	67	61	62	53	58	75	47	51	59	65.5
1931	34	28	30	37	35	33	41	38	31	35.9
1932	19	15	15	15	12	19	13	14	15	19.2
1933	35	33	35	31	31	39	35	30	35	39.3
1934	73	76	78	76	80	92	84	89	88	78.6
1935	45	47	49	43	46	59	44	51	70	53.7

Bureau of Agricultural Economics. Compiled from records of the Division of Crop and Livestock Estimates.

TABLE XXXII

CORN: ACREAGE, PRODUCTION, VALUE, AND FOREIGN TRADE, UNITED STATES, 1902–1935

Year	Acreage Harvested	Average Yield per Acre	Production: In Grain Equivalent on Entire Acreage	Production: Harvested as Grain	Price per Bushel Received by Producers Dec. 1[1]	Farm Value, Basis Dec. 1 Price	Price per Bushel at Chicago, Year Beginning November[2]	Foreign Trade Including Meal Year Beginning July[3]: Domestic Exports	Foreign Trade: Imports	Foreign Trade: Net Exports[4]: Total	Foreign Trade: Net Exports[4]: Percentage of Production
	thousand acres	bushels	thousand bushels	thousand bushels	cents	thousand dollars	cents	thousand bushels	thousand bushels	thousand bushels	per cent
1902	97,177	28.5	2,773,954	....	....	....	47	76,639	41	76,598	2.8
1903	93,555	26.9	2,515,093	....	....	....	49	58,222	17	58,210	2.3
1904	95,228	28.2	2,686,624	....	....	....	48	90,293	16	90,278	3.4
1905	95,746	30.9	2,954,148	....	....	....	44	119,894	11	119,883	4.1
1906	95,624	31.7	3,032,910	....	....	....	50	86,368	11	86,358	2.8
1907	96,094	27.2	2,613,797	....	....	....	68	55,064	20	55,044	2.1
1908	95,285	26.9	2,566,742	....	....	....	65	37,665	258	37,437	1.5
1909	*98,383*	*25.9*	*2,552,190*	....	....	....	....	....	....	....	....
1909	100,200	26.1	2,611,157	....	....	....	59	38,128	118	38,010	1.5
1910	102,267	27.9	2,852,794	....	....	....	53	65,615	53	65,562	2.3
1911	101,393	24.4	2,474,635	....	....	....	71	41,797	54	41,744	1.7
1912	101,451	29.1	2,947,842	....	....	....	53	50,780	903	49,913	1.7
1913	100,206	22.7	2,272,540	....	....	....	70	10,726	12,368	[5] 1,639	....
1914	97,796	25.8	2,523,750	....	....	....	70	50,668	9,899	40,816	1.6
1915	100,623	28.1	2,829,044	....	....	....	79	39,897	5,211	34,761	1.2
1916	100,561	24.1	2,425,206	....	....	....	111	66,753	2,270	65,092	2.7
1917	110,893	26.2	2,908,242	....	....	....	163	49,073	3,197	45,950	1.6
1918	102,195	23.9	2,441,249	....	....	....	162	23,019	3,346	19,684	.8

1919 [6]	*87,772*	*26.7*	......	*2,345,833*	......	......	......	......	......	......	......
1919	98,145	27.3	2,678,541	2,341,870	150.7	4,035,445	159	16,729	10,283	6,509	.2
1920	101,359	30.3	3,070,604	2,695,085	61.0	1,872,085	62	70,906	5,791	66,116	2.2
1921	103,155	28.4	2,928,442	2,556,924	52.7	1,544,722	55	179,490	142	179,374	6.1
1922	100,345	27.0	2,707,306	2,229,496	75.2	2,036,831	73	96,596	182	96,415	3.6
1923	101,123	28.4	2,875,292	2,429,551	83.5	2,400,513	88	23,135	240	22,896	.8
1924 [6]	*82,329*	*22.2*	....	*1,823,880*	......	......	......	......	......	......	......
1924	100,420	22.9	2,298,071	1,899,751	105.3	2,420,928	106	9,791	4,618	5,348	.2
1925	101,331	28.2	2,853,083	2,413,364	69.9	1,995,031	75	24,783	637	24,150	.8
1926	99,452	25.9	2,574,511	2,133,404	75.3	1,938,403	87	19,819	1,098	18,731	.7
1927	98,357	27.2	2,677,671	2,249,926	84.9	2,273,599	101	19,409	5,463	14,364	.5
1928	100,336	27.1	2,714,535	2,282,938	84.3	2,288,041	92	41,874	490	41,387	1.5
1929 [6]	*83,162*	*25.6*	....	*2,130,752*	......	......	......	......	......	......	......
1929	97,806	25.9	2,535,546	2,140,215	79.8	2,024,132	83	10,281	497	9,788	.4
1930	101,083	20.4	2,065,273	1,733,429	59.4	1,227,659	60	3,317	1,747	1,572	.1
1931	105,948	24.4	2,588,500	2,229,088	32.1	830,725	36	3,969	386	3,583	.1
1932	108,668	26.8	2,906,873	2,514,613	31.8	925,277	35	8,775	195	8,580	.3
1933	103,260	22.8	2,351,658	2,038,706	52.2	1,227,221	52	4,965	244	4,721	.2
1934	87,795	15.7	1,377,126	1,104,659	81.6	1,124,321	86	2,324	20,430	18,106[5]	1.3
1935 [7]	92,727	23.8	2,202,852	1,923,559	57.7	1,271,089	......	......	......	......	......

Bureau of Agricultural Economics.

Production figures are estimates of the Crop Reporting Board, revised. Italic figures are census returns.

[1] Calculations of average price and farm value not completed. Beginning with 1919 prices are weighted average prices for crop-marketing season.

[2] Prices 1866–1867 to 1898–1899 are averages of the weekly quotations for No. 2 or better in annual reports of Chicago Board of Trade; subsequent prices are compiled from the Chicago Daily Trade Bulletin, average of daily prices weighted by car-lot sales, No. 3 yellow.

[3] Compiled from Commerce and Navigation of the United States, 1866–1917, Foreign Commerce and Navigation of the United States, 1918, Monthly Summary of Foreign Commerce of the United States, June issues 1919–1926, January and June issues, 1927–1934 and official records of the Bureau of Foreign and Domestic Commerce. Corn—General imports 1866–1909 and 1912–1933, imports for consumption 1910 and 1911, and 1934 Corn meal—Imports for consumption, 1866–1934. Corn meal converted to terms of grain on the basis of 4 bushels of corn to a barrel of meal.

[4] Total exports (domestic plus foreign) minus total imports. Beginning 1933–1934 net exports are domestic exports minus imports for consumption.

[5] Net imports, i.e., total imports minus total exports (domestic plus foreign).

[6] Corn harvested for grain; total acreage of corn in 1924 is 98,401,627 acres; 1929, 97,740,740 acres.

[7] Preliminary.

TABLE XXXIII

Corn, No. 3 Yellow: Weighted Average Price per Bushel of Reported Cash Sales, Chicago, by Months, 1910–1936

Crop Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Average
	cents	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*
1910–11	49.0	45.0	45.0	45.0	45.0	50.0	54.0	55.0	63.0	65.0	67.0	73.0	53.0
1911–12	68.0	61.0	62.0	64.0	68.0	78.0	79.0	75.0	68.0	79.0	74.0	65.0	71.0
1912–13	52.0	46.0	46.0	48.0	49.0	55.0	57.0	60.0	62.0	74.0	75.0	70.0	53.0
1913–14	72.0	66.0	62.0	62.0	64.0	67.0	70.0	72.0	71.0	82.0	79.0	73.0	70.0
1914–15	67.0	64.0	71.0	74.0	72.0	75.0	77.0	74.0	78.0	81.0	74.0	65.0	70.0
1915–16	63.0	69.0	74.0	74.0	73.0	76.0	75.0	74.0	81.0	85.0	86.0	96.0	79.0
1916–17	98.0	92.0	98.0	100.0	109.0	140.0	159.0	170.0	199.0	206.0	210.0	203.0	111.0
1917–18	221.0	177.0	177.0	181.0	170.0	165.0	160.0	162.0	170.0	172.0	158.0	141.0	163.0
1918–19	133.0	145.0	143.0	127.0	153.0	162.0	174.0	178.0	192.0	195.0	155.0	141.0	162.0
1919–20	146.0	147.0	151.0	146.0	158.0	169.0	202.0	189.0	158.0	158.0	131.0	91.0	159.0
1920–21	77.0	75.0	65.0	63.0	62.0	57.0	60.0	62.5	60.0	56.0	53.1	45.2	62.0
1921–22	47.4	47.3	47.8	54.9	57.1	57.8	61.6	60.6	64.1	62.3	63.5	68.9	55.1
1922–23	71.1	72.7	70.1	72.5	72.9	78.7	81.5	84.0	87.7	88.0	88.6	104.4	73.4
1923–24	82.0	70.9	76.1	78.2	77.3	77.4	77.3	81.6	109.4	117.3	113.6	110.3	87.7
1924–25	111.5	120.4	123.8	122.0	116.8	105.3	115.4	112.8	107.5	102.0	90.6	82.2	106.4
1925–26	82.8	76.5	78.7	74.6	71.6	71.5	70.6	70.0	78.3	80.2	79.0	76.8	74.7
1926–27	70.6	75.1	74.0	72.7	68.5	71.1	86.7	98.9	101.9	109.2	97.4	84.4	86.7
1927–28	84.0	86.4	88.6	95.2	98.5	105.9	107.5	103.5	106.4	102.3	100.1	95.9	101.0
1928–29	84.4	83.4	93.1	94.4	94.1	89.8	87.4	91.1	98.8	101.2	100.6	94.5	92.5
1929–30	87.6	87.5	85.1	81.8	79.7	82.0	78.6	79.1	82.0	98.9	94.0	82.0	83.2
1930–31	70.9	69.5	65.4	60.7	59.8	58.3	56.2	57.7	56.8	45.7	41.8	38.1	59.6
1931–32	42.7	37.1	37.0	34.2	33.2	32.5	31.4	30.2	31.9	31.9	30.0	25.7	35.6
1932–33	24.9	23.0	23.6	23.1	25.7	34.5	42.2	43.4	55.8	51.0	47.5	40.2	35.4
1933–34	44.4	46.5	49.7	48.6	48.9	47.3	51.3	58.4	64.1	76.1	80.0	77.9	52.0
1934–35	83.4	93.3	90.8	87.7	83.3	89.0	87.6	85.1	84.8	80.6	83.2	82.0	86.3
1935–36	62.1	59.0	60.8	61.3	60.8	63.2	63.2						
1936–37													
1937–38													
1938–39													
1939–40													

Bureau of Agricultural Economics. Compiled from Chicago Daily Trade Bulletin. Average of daily prices weighted by car-lot sales.

TABLE XXXIV

Hog-corn Ratios: Farm Price Basis,[1] United States, 1909–1910 to 1935–1936

Year Beginning October	Oct. 15	Nov. 15	Dec. 15	Jan. 15	Feb. 15	Mar. 15	Apr. 15	May 15	June 15	July 15	Aug. 15	Sept. 15	Average
	bushels	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*
1909–10	....	....	....	12.2	12.0	13.6	14.4	13.3	12.9	12.2	11.6	13.0	. .
1910–11	14.2	15.1	14.9	15.3	14.4	13.7	12.1	10.7	9.8	9.4	9.9	9.9	12.4
1911–12	9.3	9.3	9.2	9.1	8.8	8.6	9.0	8.4	8.1	8.3	9.1	10.1	8.9
1912–13	12.0	13.2	14.1	13.6	13.9	14.4	14.4	12.7	12.3	12.1	11.1	10.2	12.8
1913–14	10.4	10.5	10.3	10.8	11.3	11.2	10.9	10.3	9.9	10.1	10.2	10.2	10.5
1914–15	10.0	10.4	10.2	9.5	8.6	8.4	8.5	8.7	8.7	8.7	8.5	9.2	9.1
1915–16	10.8	10.6	10.1	9.8	10.5	11.4	11.5	11.4	11.0	10.9	10.6	11.1	10.8
1916–17	10.4	10.0	9.8	9.9	10.5	11.5	10.3	8.8	8.3	7.4	7.7	9.0	9.5
1917–18	10.1	11.2	12.0	11.2	10.3	10.1	10.2	10.3	10.0	9.9	10.4	10.8	10.5
1918–19	11.0	11.5	11.3	11.1	11.3	11.2	11.1	10.8	10.2	10.5	10.2	9.3	10.8
1919–20	9.7	10.0	9.2	9.3	9.2	8.8	8.4	7.6	7.1	7.8	8.5	10.1	8.8
1920–21	13.0	15.1	13.3	13.5	13.5	14.3	13.0	12.5	11.6	13.0	14.8	14.0	13.5
1921–22	15.9	16.0	15.2	15.4	16.4	16.3	15.1	14.9	14.7	14.4	13.4	13.2	15.1
1922–23	13.4	12.1	11.3	11.1	10.6	10.0	9.4	8.5	7.4	7.7	7.9	9.1	9.9
1923–24	8.5	8.5	8.9	9.0	8.5	8.6	8.6	8.5	8.1	6.7	8.0	7.7	8.3
1924–25	8.7	8.7	7.9	8.3	8.4	10.6	11.2	10.0	9.7	11.5	11.4	11.6	9.8
1925–26	13.4	14.3	14.9	15.8	17.2	17.5	17.5	17.8	18.7	17.7	14.7	15.8	16.3
1926–27	16.2	17.3	17.0	17.1	16.8	16.7	15.9	12.9	9.4	9.3	9.5	10.3	14.0
1927–28	11.6	12.2	10.8	10.4	9.6	8.7	8.4	8.6	8.5	9.4	10.2	11.7	10.0
1928–29	11.3	11.3	10.4	10.2	10.2	11.3	11.7	11.6	11.3	11.3	10.7	9.8	10.9
1929–30	9.9	10.5	10.9	11.4	12.2	12.8	11.7	14.6	11.5	10.9	9.5	10.3	11.1
1930–31	10.7	12.4	11.5	11.8	11.6	12.0	12.0	11.3	10.6	11.5	12.3	12.6	11.7
1931–32	14.1	11.9	10.9	11.2	10.9	12.1	11.4	9.8	9.6	14.1	13.4	13.5	11.9
1932–33	15.0	15.7	14.5	14.0	15.2	15.6	11.4	10.0	9.9	7.2	7.8	8.0	12.0
1933–34	10.7	9.1	7.0	7.0	8.5	8.2	7.4	6.5	6.3	6.7	6.3	7.8	7.6
1934–35	6.8	6.7	6.0	8.1	8.4	9.8	9.2	9.3	10.0	10.2	12.6	13.2	9.2
1935–36	13.3	15.1	16.5										
1936–37													

Bureau of Agricultural Economics. Compiled from records of the Division of Crop and Livestock Estimates.

[1] Number of bushels of corn required to buy 100 pounds of live hogs based on average farm prices of corn and hogs for the month.

TABLE XXXV

CORN: ACREAGE, WORLD AND SPECIFIED COUNTRIES. AVERAGE 1925–26 TO 1929–30 AND ANNUAL 1932–33 TO 1935–36.

Country	Acreage				
	Average 1925–26 to 1929–30	1932–33	1933–34	1934–35	1935–36[1]
NORTHERN HEMISPHERE	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*
North America:					
Canada	174	130	137	161	168
United States	99,456	108,668	103,260	87,795	92,727
Mexico	7,528	8,013	7,903	7,340	....
Guatemala	314	332	....	......	....
Total North American countries reporting area and production, all years	99,630	108,798	103,397	87,956	92,895
Estimated North American total	108,700	119,500	112,900	96,900	101,800
Europe:					
France	847	840	832	839	831
Spain	1,057	1,102	1,067	1,072	1,074
Portugal	827	930	1,080	...	....
Italy	3,758	3,579	3,536	3,678	3,617
Austria	146	165	159	160	162
Czechoslovakia	351	331	316	359	372
Greece	503	656	646	585	....
Poland	218	240	225	224	231
U. S. S. R., European and Asiatic	8,387	9,095	9,777	9,092	8,464
Total Europe, excluding Danube Basin	2,401	2,438	2,374	2,430	2,439
Danube Basin					
Hungary	2,662	2,905	2,816	2,777	2,879
Yugoslavia	5,180	6,228	6,272	6,563	6,671
Bulgaria	1,671	1,839	1,796	1,692	1,775
Rumania	10,606	11,802	11,928	12,368	12,771
Total	20,119	22,774	22,812	23,400	24,096
Total European countries reporting area and production, all years	22,520	25,212	25,186	25,830	26,535
Estimated European total, excluding U. S. S. R.	27,900	30,900	31,000	31,500	32,300
Africa:					
Kenya	190	164	113	123	129
Morocco	561	856	887	986	996
Egypt	2,102	2,043	1,638	1,632	....
Estimated African total	4,200	5,100	5,100	4,800	4,800

TABLE XXXV—*Continued*

Country	Acreage				
	Average 1925–26 to 1929–30	1932–33	1933–34	1934–35	1935–36[1]
NORTHERN HEMISPHERE—*Continued*	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*
Asia:					
Turkey	812	830	942	1,079	....
India	6,363	6,892	6,948	6,049	....
Philippine Islands	1,311	1,426	1,555	....	....
Manchuria	2,467	2,422	2,723	2,774	2,950
Japan	125	111	117	....	....
Chosen	251	270	276	292	....
Kwantung	203	249	249	....	....
Estimated Asiatic total	12,100	12,800	13,700	12,700	12,600
Total Northern Hemisphere countries reporting area and production, all years	125,368	137,452	132,306	117,669	123,505
Estimated Northern Hemisphere total, excluding U. S. S. R.	152,800	168,300	163,000	145,900	151,400
SOUTHERN HEMISPHERE					
Brazil	6,466[2]	....	....	11,856	....
Chile	88	164	118	115	....
Uruguay	502	519	508	568	....
Argentina	9,429	9,373	10,161	14,091	....
Union of South Africa:					
European	5,148	6,074	6,506	6,672	....
Native	....	.... .	....	....	......
Southern Rhodesia[3]	289	251	....	....	.. ....
Java and Madura	4,540	4,946	5,447	4,560	3,854
Australia	319	228	304	. .	..
Total Southern Hemisphere countries reporting area and production, all years through 1934–35	15,167	16,130	17,293	21,446	....
Estimated Southern Hemisphere total	30,100	33,700	34,900	42,700	38,700
Total Northern and Southern Hemisphere countries reporting area and production, all years through 1934–35	170,457	185,200	181,490	169,086	....
Estimated world total, excluding U. S. S. R.	183,200	202,000	197,900	188,600	190,100

Bureau of Agricultural Economics Official sources and International Institute of Agriculture. "U. S. S. R." means Union of Soviet Socialist Republics. Figures refer to the year of harvest.

[1] Preliminary.

[2] Four-year average.

[3] European cultivation only.

TABLE XXXVI

CORN, YELLOW: AVERAGE PRICE PER BUSHEL, BUENOS AIRES, BY MONTHS, 1919–1920 TO 1935–1936

Year Beginning November	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Average
	cents	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*
1919–20	....	....	69.7	71.0	86.1	108.2	119.0	111.8	96.4	90.5+	92.4	82.0	
1920–21	77.9	83.1	88.7	92.0	90.8	77.3	62.0	62.7	65.0	66.2	65.9	57.6	74.1
1921–22	60.1	63.0	62.9	73.4	80.5−	77.7	74.0	70.7	76.8	77.5+	75.8	73.2	72.1
1922–23	70.3	74.1	78.7	81.6	81.2	80.9	76.2	74.9	72.6	69.1	73.6	77.5−	75.9
1923–24	81.0	79.2	78.6	81.9	76.9	68.8	65.0	63.8	75.5+	84.4	93.0	105.0	79.4
1924–25	106.4	98.4	111.5−	108.1	96.2	92.2	99.9	91.7	92.3	95.8	90.1	82.6	97.1
1925–26	84.2	85.9	79.2	73.0	65.5	70.8	68.2	68.4	68.4	69.3	65.1	60.2	71.5+
1926–27	55.4	55.2	59.8	63.1	62.6	61.9	65.8	68.6	69.4	76.1	77.1	75.8	65.9
1927–28	76.5−	83.4	89.9	97.7	101.8	88.9	90.2	90.7	89.5+	85.0	86.2	94.6	89.5+
1928–29	96.8	93.4	97.7	96.0	89.5+	85.2	78.7	80.5+	90.1	86.8	86.7	84.5+	88.8
1929–30	75.1	71.8	65.0	62.3	59.1	59.8 [1]	59.1	55.9	53.5	56.1	50.5	42.8	59.2
1930–31	34.2	33.2	29 2	20.6	34.8	33.4	30.2	30.3	29.6	26.5	23.5	25.3	30.1
1931–32	32.0	28.5	27.2	29.5	32.7	31.0	29.3	30.2	31.4	32.1	32 1	29.8	30.5−
1932–33	27.7	25.8	28 6	28 2	26.8	26.7	29.9	30.7	36.8	34.6	36 6	33.9	30.5+
1933–34	38.1	37.3	38.5+	43.4	47.4	39.7	39.7	43.3	47.5−	60.9	57.9	52.2	42.5−
1934–35	51.2	56.2	48 6	43 2	41.7	39.1	37.8	37.7	36.9	37.0	37.9	37.5	42.1
1935–36	36.7	37.2	37 0	37 2	39 4	41 9	42.1	42.4	45.9	52 3			
1936–37													
1937–38													
1938–39													
1939–40													

Bureau of Agricultural Economics. All prices converted.

TABLE XXXVII

Iowa Temperature in Degrees Fahrenheit, 1890–1935

Year	Mar.	Apr.	May	June	July	Aug.	Sept.
1890	28.1	51.2	56.5	72.2	75.2	68.1	59.5
1891	26.8	50.6	58.3	69.1	68.5	69.1	67.3
1892	31.9	45.4	54.0	69.2	73.0	71.4	64.7
1893	31.8	45.5	56.6	71.2	75.0	69.4	64.7
1894	41.0	51.7	61.1	73.2	76.4	74.6	65.1
1895	34.4	54.2	61.7	69.7	72.1	71.9	66.8
1896	30.9	54.5	65.5	69.1	73.6	71.7	58.5
1897	32.0	47.9	58.5	69.1	75.6	68.9	70.9
1898	37.5	48.1	59.6	71.4	73.4	71.2	65.3
1899	23.0	48.7	60.2	70.7	73.1	74.4	62.5
1900	30.7	52.2	63.2	69.7	73.4	77.4	64.4
1901	34 2	49.9	60.7	72.3	82 4	73.8	63.3
1902	39.1	48.2	63.8	65.2	73.1	69.1	59.1
1903	38.8	49.8	61.6	64.6	72.9	69.1	60.8
1904	34.8	44.1	59.6	67.1	70 6	69.1	64.0
1905	41.5	47.5	58.3	69.9	70 6	74.3	65.8
1906	27.1	52.5	60.8	67.9	70.9	74.1	67.2
1907	40.6	41.5	53.5	66.5	73.7	71.1	62.8
1908	37.9	50.5	59.4	67.1	73.0	70.0	67.9
1909	32.5	43.8	57.9	69.1	72.3	76.1	62.4
1910	48 9	52.5	55.4	69.5	74.5	71.9	63.2
1911	39 4	46.8	64 9	75.7	75.5	71.7	65.8
1912	24 9	49.9	62.7	66.2	74.6	71.0	62.1
1913	31.9	50.2	59.4	71.5	76.1	76.6	64.5
1914	34.7	48.6	62.2	72 2	76.6	73.7	64.5
1915	29.3	57.2	56.1	65.1	69.5	65.9	63.7
1916	35.2	47.1	59.9	64.5	79.7	74.0	62.5
1917	34.6	45.5	55.1	66.0	74.3	69.4	62.6
1918	42.9	44.8	64.9	70.8	73.1	76.0	58.6
1919	37.5	48.4	58.2	71.9	77.4	71.5	67.5
1920	38.0	42.4	59.4	70.7	72.3	69.3	66.5
1921	42.8	52.4	63.3	74.7	77.9	72.1	67.3
1922	38.3	49.9	63 4	72.2	71.5	73.8	67.1
1923	29.4	48.4	59.6	70.9	76.5	70.6	64.2
1924	31.9	50.5	54.1	66.8	70.2	71.7	59.1
1925	40 1	56.5	57.8	70.4	74.1	72.4	69.0
1926	32.1	46.1	64.5	66.2	74.8	73.5	63.0
1927	39.6	49.2	58.4	66.4	72.9	67.9	67.4
1928	38.9	44.3	62.6	64.5	73.9	72.7	60.5
1929	39.1	51.2	57.7	67.6	74.1	71.9	62.4
1930	37.3	52.1	60.2	69.0	77.9	74.4	66.3
1931	34.9	50.9	57.5	75.0	77.2	72.6	71.0
1932	28.4	50.0	62.3	72.0	75.8	72.2	62.2
1933	36.0	48.8	60.5	77.8	76.1	70.5	69.4
1934	34.4	50.4	69.6	77.2	79.7	73.4	61.0
1935	40.7	46.7	55.0	65.9	79.4	73.6	65.0

Bureau of Agricultural Economics. Compiled from records of the Weather Bureau.

TABLE XXXVIII

Iowa Rainfall in Inches, 1890–1935

Year	Mar.	Apr.	May	June	July	Aug.	Sept.
1890	1.49	1.73	3.64	6.67	2.04	3.25	2.71
1891	2.60	2.15	3.18	5.39	4.22	4.24	1.33
1892	2.22	4.75	8.77	5.19	5.29	2.24	1.53
1893	2.14	4.21	3.45	3.91	3.33	2.32	2.34
1894	2.03	3.07	1.87	2.67	0.63	1.58	3.57
1895	0.83	2.62	3.19	4.32	3.40	4.43	3.03
1896	1.10	5.02	6.69	3.11	6.90	3.52	4.09
1897	2.39	5.35	1.92	3.81	3.26	1.86	2.04
1898	1.94	2.56	4.67	4.72	2.98	3.44	2.69
1899	1.62	2.40	6.23	5.04	3.07	3.68	0.93
1900	2.06	2.67	3.31	3.98	6.15	4.65	4.98
1901	2.64	1.79	2.35	3.71	2.34	1.29	4.77
1902	1.45	1.71	5.39	7.16	8.67	6.58	4.35
1903	1.38	2.98	8.55	2.86	4.83	6.64	3.81
1904	2.18	3.63	3.78	3.45	4.41	3.43	2.78
1905	2.04	3.03	5.95	5.53	2.91	4.05	3.81
1906	2.34	2.42	3.54	3.92	3.04	3.95	4.16
1907	1.35	1.32	3.48	5.35	7.27	4.33	2.75
1908	1.58	2.24	8.34	5.66	3.66	4.77	1.20
1909	1.53	4.58	4.34	6.41	4.77	1.81	3.58
1910	0.17	1.48	3.41	1.99	1.86	3.88	3.59
1911	0.93	3.09	3.76	1.82	2.27	3.32	5.12
1912	2.01	2.66	3.33	2.74	3.71	3.78	3.98
1913	2.48	3.29	6.24	3.31	1.82	2.68	3.31
1914	1.69	2.52	3.31	5.57	2.27	2.19	7.88
1915	0.96	1.41	7.34	4.16	8.32	2.81	6.03
1916	1.57	2.62	4.93	3.71	1.78	2.58	3.89
1917	1.84	4.55	3.87	6.65	2.27	2.29	2.90
1918	0.63	2.32	6.87	5.29	3.17	3.61	1.87
1919	2.33	4.78	3.11	6.13	2.86	2.59	5.34
1920	3.02	4.59	3.26	3.56	4.22	3.35	3.30
1921	1.57	3.34	4.23	3.76	2.53	5.04	6.72
1922	1.97	3.06	3.53	1.82	6.31	3.06	2.03
1923	2.87	2.09	2.84	4.93	1.75	5.42	5.79
1924	2.65	1.38	1.71	8.10	3.67	5.35	3.13
1925	0.93	2.20	1.16	6.64	2.66	3.47	5.04
1926	1.06	0.91	2.76	4.52	3.72	3.80	9.76
1927	1.92	4.84	4.69	2.42	1.96	2.36	4.56
1928	1.44	2.24	2.47	5.38	4.43	6.42	3.08
1929	1.44	4.62	2.47	3.08	4.31	2.44	3.74
1930	0.89	2.67	3.72	5.83	1.49	2.42	2.31
1931	1.68	2.29	2.96	3.73	2.72	3.30	6.69
1932	1.46	1.96	3.99	5.17	3.12	7.10	2.05
1933	3.09	1.21	4.36	1.64	3.45	3.01	4.16
1934	1.09	1.07	1.02	3.49	3.85	2.84	5.07
1935	1.47	1.92	4.84	7.00	3.35	2.42	3.46

Bureau of Agricultural Economics. Compiled from records of the Weather Bureau.

TABLE XXXIX

Ohio Temperature in Degrees Fahrenheit, 1890–1935

Year	Mar.	Apr.	May	June	July	Aug.	Sept.
1890	34.5	51.3	59.2	73.3	73.0	68.8	62.1
1891	35.0	52.0	58.0	71.0	69.0	70.0	67.0
1892	35.0	49.0	59.0	73.0	73.0	71.0	64.0
1893	38.0	50.2	58.3	70.6	74.5	70.7	65.2
1894	45.1	50.6	60.0	71.3	74.3	71.2	67.8
1895	35.5	51.7	61.1	72.0	71.6	73.5	69.0
1896	32.4	56.9	67.9	69.5	73.2	71.8	62.7
1897	41.5	49.3	56.3	68.1	75.5	69.4	66.9
1898	45.0	47.2	61.0	71.9	76.0	73.5	67.8
1899	36.9	53.3	63.3	71.5	74.1	73.7	64.1
1900	32.9	50.1	62.9	69.8	74.1	76.3	69.3
1901	39.5	46.7	59.0	70.9	78.1	73.1	64.8
1902	41.9	48.2	62.6	66.9	74.0	68.9	63.6
1903	46.7	49.9	63.9	64.4	72.9	70.7	65.6
1904	39.7	44.4	60.7	68.4	71.4	68.8	65.5
1905	42.7	48.5	60.7	69.2	73.0	71.7	65.3
1906	31.3	52.1	61.3	69.8	72.1	74.6	68.9
1907	45.9	42.5	54.5	65.6	72.6	69.5	65.5
1908	43.4	51.0	62.8	69.2	73.9	71.2	68.0
1909	37.3	49.1	58.7	70.1	70.7	71.9	63.2
1910	48.2	51.5	56.0	65.9	73.8	71.4	66.3
1911	37.4	47.7	66.3	70.9	74.0	72.5	67.5
1912	32.9	51.9	62.5	66.6	73.4	69.2	67.4
1913	40.1	50.0	60.3	69.8	74.5	73.3	64.1
1914	36.0	50.1	62.2	71.1	74.0	72.8	63.4
1915	33.2	54.8	57.8	66.8	71.5	67.5	67.0
1916	34.7	49.3	61.8	64.7	76.9	74.4	63.7
1917	39.6	48.7	54.1	66.9	72.3	71.3	61.9
1918	44.0	48.7	66.4	68.8	71.3	76.6	58.4
1919	41.0	49.7	58.6	74.2	75.1	70.5	66.7
1920	41.7	45.8	58.3	68.9	70.4	70.3	66.5
1921	48.9	55.1	62.1	73.4	77.8	70.6	70.1
1922	42.2	52.6	64.0	70.9	72.9	70.5	68.2
1923	37.7	48.4	58.3	71.0	72.8	70.7	65.7
1924	36.2	49.8	54.6	68.0	70.3	72.0	60.8
1925	41.8	54.2	55.6	73.0	72.0	72.0	70.1
1926	33.2	44.4	60.5	65.9	72.9	74.0	66.6
1927	42.7	49.8	60.1	64.6	72.6	66.4	68.1
1928	38.1	46.5	59.1	65.0	73.7	74.0	61.6
1929	45.8	53.2	58.5	67.1	72.9	68.0	65.5
1930	38.3	52.1	62.8	70.0	75.6	72.0	67.7
1931	36.2	50.1	59.1	70.8	77.2	72.7	70.3
1932	33.7	48.5	61.6	71.0	73.7	72.8	66.0
1933	38.4	50.9	63.6	74.4	74.7	72.1	69.1
1934	35.3	49.5	64.1	76.0	78.6	71.9	67.8
1935	46.2	47.5	56.3	67.4	76.7	73.2	64.4

Bureau of Agricultural Economics. Compiled from records of the Weather Bureau.

TABLE XL

Ohio Rainfall in Inches, 1890–1935

Year	Mar.	Apr.	May	June	July	Aug.	Sept.
1890	5.29	3.45	5.52	4.50	1.99	4.66	5.56
1891	4.19	2.13	2.20	4.82	3.82	3.07	1.50
1892	2.86	3.32	6.32	5.61	3.80	2.99	2.36
1893	2.09	6.37	4.97	3.34	2.49	2.17	1.57
1894	2.16	2.31	4.00	2.65	1.56	1.67	3.31
1895	1.59	2.11	1.80	2.47	2.00	2.96	1.66
1896	3.34	2.78	2.67	4.81	8.11	3.38	5.13
1897	5.17	3.27	3.93	2.85	4.65	2 72	0.78
1898	6.23	2.38	4.10	2.86	3.98	4.50	2.56
1899	4.64	1.61	4.32	2.94	4.17	1.82	2.68
1900	2.35	1.89	2.40	3.01	4.62	3.68	1.76
1901	2.66	3.40	3.96	4.44	2.72	3.33	2.86
1902	2.76	2.21	3.09	7.48	4.69	1.67	4.55
1903	3.51	4.01	2.82	4.02	3.67	3.20	1.52
1904	5.67	3.53	3.79	2.88	4.13	2.74	1.95
1905	2.50	3.10	5.63	4.72	3.93	4.46	2.86
1906	3.97	1.89	2.17	3.42	5.14	4.77	2.92
1907	5.55	2 74	3.47	4.57	5.36	2.48	3.92
1908	5.43	3.71	4 72	2.51	4.08	2.59	0.58
1909	2.77	4.13	4.72	5.86	3.76	3.56	1.78
1910	0.26	3.49	3.80	2.66	3.17	1.58	4.05
1911	2.33	4.35	1.69	3.92	2.40	5 39	4.87
1912	4.17	4.47	3.12	3.17	5.70	4.08	3.11
1913	8.40	3.35	3.53	1.87	5.20	2.52	2.37
1914	2.41	4.01	3.11	3.14	2.19	5.08	1.41
1915	1.44	1.42	3.99	4.36	6.32	4 52	4.51
1916	4.15	2.35	4 27	4.86	1.92	3.11	2.56
1917	3.65	3.38	4.18	4.99	3.88	2.70	1.86
1918	2.49	3.23	4.49	2.68	2.61	3.64	3.75
1919	4.04	3.02	4.78	2.88	4.02	4.46	1.90
1920	2.72	5.78	2.45	4.53	4.50	4.36	2.56
1921	5.94	3.90	3.20	2.81	2.93	4 21	4.29
1922	5.15	4.52	4.69	2.98	3.70	3.26	2.81
1923	3.00	2 60	3 56	3.38	3.57	4 34	3.12
1924	3.53	2.71	4.10	6.38	2.84	2.12	4.80
1925	2.63	2.04	2.61	2.85	4.69	2.34	3.76
1926	2.28	3.17	2.51	3.11	4.29	5.92	7.28
1927	3.83	4.13	4.73	3.62	4.54	2.50	2.18
1928	2.84	3.06	1.77	6.79	4.75	2.65	0.90
1929	2.83	4.88	5.33	4.01	4.84	2.73	3.02
1930	2.77	2.11	1.80	2.34	1.53	2.35	2.72
1931	2.14	4.31	3.07	3.58	3.77	4.99	4.01
1932	2.92	2.29	1.78	3.79	4.29	2.06	2.80
1933	5.54	3.74	6.44	1.78	2.47	3.43	4.65
1934	2.81	2.25	0.79	3.52	2.64	4.20	3.82
1935	3.35	1.95	4.88	3.96	4.93	6.06	2.88

Bureau of Agricultural Economics. Compiled from records of the Weather Bureau

TABLE XLI

GOVERNMENT CORN CONDITION AS REPORTED FIRST OF EACH MONTH DURING GROWING SEASON, IOWA AND OHIO, 1891–1935

Year	Iowa				Ohio			
	July 1	Aug. 1	Sept. 1	Oct. 1	July 1	Aug. 1	Sept. 1	Oct. 1.
1891	94	90	90	95	93	93	95	97
1892	75	79	78	79	80	81	79	80
1893	98	102	96	93	93	85	64	70
1894	100	45	40	47	92	79	70	71
1895	105	107	96	96	91	89	83	87
1896	94	103	103	102	106	105	104	106
1897	75	78	70	74	76	85	84	81
1898	100	92	82	80	90	89	92	92
1899	81	82	83	85	85	90	87	86
1900	102	105	104	100	90	98	95	95
1901	87	57	55	59	78	73	60	63
1902	90	93	91	76	87	91	93	88
1903	74	72	67	71	75	73	67	70
1904	86	87	85	86	85	86	78	77
1905	88	89	89	90	82	85	90	91
1906	96	95	95	97	86	92	99	99
1907	78	78	76	70	75	78	77	78
1908	83	83	80	80	87	85	82	82
1909	86	85	79	77	90	90	87	86
1910	84	80	82	86	85	86	72	79
1911	98	68	68	70	89	80	83	86
1912	83	89	93	91	77	81	85	90
1913	89	85	76	77	89	90	81	80
1914	100	91	81	84	87	80	81	85
1915	74	72	65	63	85	86	86	88
1916	80	84	82	83	79	74	68	68
1917	86	87	82	80	85	87	83	82
1918	97	95	83	83	86	79	72	76
1919	87	87	89	90	89	86	90	94
1920	90	94	90	93	86	88	90	92
1921	102	92	92	91	87	74	84	88
1922	91	94	94	96	82	82	79	83
1923	91	90	89	90	87	92	95	87
1924	72	74	71	67	67	59	53	54
1925	95	90	88	90	90	96	101	101
1926	84	76	79	78	70	75	84	84
1927	72	73	67	75	63	65	62	68
1928	90	95	93	93	77	83	79	78
1929	83	87	81	83	79	76	72	73
1930	86	73	61	69	78	53	45	56
1931	91	82	69	75	87	90	92	92
1932	89	86	90	94	79	81	69	74
1933	82	80	78	83	62	58	65	71
1934	78	60	46	48	73	66	68	71
1935	69	81	76	81	79	87	89	89

Bureau of Agricultural Economics.

INDEX

T